Consolidation Return on Investment (cROI) Programming Tool:
Development and Use

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Photo credit line: 090313-N-9198L-071 GROTON Conn. (March 13, 2009) Capt. Mark S. Ginda, commanding officer of Naval Submarine Base New London, begins the demolition of building 442 as he takes the controls of an EC460BLC excavator. The demolition of this building, as well as others slated for demolition, is part of the Navy's Shore Vision 2035, a program to reduce base infrastructure by reusing the land under unneeded buildings. This will restructure naval bases to meet the changing needs of the Navy, reduce costs, and decrease the Navy's infrastructure footprint. (U.S. Navy photo by Electronics Technician 3rd Class Alexander Lockman/Released)

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Summary

The Navy has recently begun development of a new Optimal Shore Footprint (OSF) strategy. The intent of this initiative is to develop an enduring, top-down strategic approach to effectively balance mission readiness, operational and fiscal efficiency, and innovation in order to minimize the overall Navy shore infrastructure footprint.

To support this evolving OSF strategy, the Shore Readiness Division of the Office of the Chief of Naval Operations (OPNAV N46) asked CNA to develop a new consolidation return on investment (cROI) programming tool. This new evaluation tool will be used to compare submitted consolidation/demolition projects against each other in order to select the best projects for programming. The Navy OSF working group determined that project contributions to shore footprint reduction, facility mission criticality, facility category code utilization improvement, facility condition rating, and facility age should be measured, in addition to financial return on investment.

We expanded upon an earlier CNA-developed demolition return on investment (dROI) evaluation tool in order to address the working group's recommendations. We added the following new metrics to the original dROI tool:

- Footprint reduction
- Facility mission criticality
- Facility condition rating
- Facility age

The finished cROI evaluation tool is a single Microsoft Excel workbook with 10 worksheet tabs and a hyperlink to the project DD Form 1391[1] scope write-up. We created the workbook with the idea that for each new project the user will generate a new evaluation workbook file and combine them into one folder for retention and future refer-

ral. We also created a simplified field version that the sponsor can distribute to shore installations for use while developing future consolidation projects.

The cROI tool produces a financial return on investment (FROI) threshold check—measured in years to payback—and a single consolidated project benefit ranking score that falls between zero and one. A higher score reflects greater benefits in supporting the OSF strategy. A higher score also means that the project is a better candidate for programming.

We used several new concepts to improve the usability and accuracy of the cROI tool. These include the following:

- Installation base operating savings are allocated to individual facilities by plant replacement value (PRV) rather than by square foot measures.
- We introduced the concept of using square foot equivalents to measure footprint reduction. This conversion method allows demolished facilities that are measured in units of measure other than square feet to be changed to a square foot equivalent measure. These facilities that were not measured in square feet and were previously excluded are now included in the total measure for footprint reduction.
- We generated the concept of using normal distribution curves based on historical consolidation/demolition project execution results to normalize the current project's scores.
- We provided for user-determined adjustable programming levels for the FROI measure so that the anticipated cost avoidances for sustainment (ST), facility modernization (FM), and base operating services (BOS) can be adjusted to match current programming levels.

1. The DD Form 1391 is the standard Department of Defense form used to document the nature, location, scope, complexity, costs, and urgency of a facilities project.

- We provided adjustable factor weights, which allow the user to determine the amount of contribution allowed for each of the six metrics within the final consolidated project benefit score.

We tested the evaluation tool on a group of 18 proposed consolidation projects, which were provided to us by OPNAV. We found that ten of the 18 projects would provide a good candidate pool of projects. Even though, through use of this cROI tool, we can now list these projects in descending order of benefit to the OSF strategy, this is not enough to build future project packages for programming. The tool does not offer a way of selecting which projects, when taken together, will also meet budget and strategic requirements.

Therefore, we still need to apply market basket approaches, which take into account available funding and other strategic considerations for building actual fiscal year programs. We provide some additional background information on how to use the cROI project evaluation tool with revealed preference/market basket approaches for developing program packages from suitable discrete investment projects.

In considering our results, we provide five recommendations relating to the future use of the cROI evaluation tool.

- Develop a process that facilitates the identification of more and better consolidation projects.
- Use the OSF process to support more direct development of consolidation projects.
- Continue to work on improving the individual factor weights.
- Update the cROI tool as future projects are completed by expanding the normalization table.
- Consider future modification of the project evaluation process, including a revealed preference/market basket approach for program generation.

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Introduction

Given the current economic conditions in the United States and the budget constraints placed on the Department of Defense (DOD), the Navy must be more adept in aligning its operational force structure with its shore infrastructure in order to achieve the current Maritime Strategy. The Navy's infrastructure must be carefully studied, and the Navy must ensure that it is properly sized and configured to support present and future needs without supporting unnecessary additional capacity.

To that end, the Navy is looking to eliminate all unnecessary shore infrastructure in an effort to reduce the long-term costs associated with base operating expenses, sustainment, and restoration. However, the Navy wants to take a prudent and rational approach to eliminating unneeded infrastructure. It would like to eliminate excess while still preserving the capability for any potential surge needs.

Background

The Director, Shore Readiness Division, OPNAV N46, tasked CNA to develop a robust, quantitative procedure for evaluating consolidation projects and determining, with a mathematical decision-support approach, the set of consolidation projects that should be recommended for funding.

Research approach

In addition to including the standard FROI metric that is commonly used in the private sector to evaluate capital budgeting decisions, N46 has asked CNA to include additional metrics and criteria in the evaluation process. Beyond FROI, the Navy must consider other factors in its decisions about where to reduce the shore infrastructure. Whereas private corporations are focused on maximizing stock-

holder wealth, the Navy's investment decision criteria must include factors related to its mission (i.e., securing the high seas and supporting war operations).

These additional factors are related to the Optimal Shore Footprint (OSF) strategy, which states that the shore footprint must incorporate mission effectiveness, operational and fiscal efficiency, and technical innovation into the decision process. The central goal of OSF is to meet the required shore facilities at minimal cost.

Although the OSF concept is still in its infancy, the basic premise of the effort is to better align shore assets with the overall mission of the Navy. This includes developing systems that provide managerial decision-makers with real-time information on the status of all facilities in the naval inventory. This leads to better decisions when allocating limited resources to sustainment and restoration efforts.

Altogether, the Navy identified six criteria that should be incorporated into the process of determining which consolidation projects should be funded. These six criteria are:

- Financial return on investment (FROI)
  - FROI is based on the estimated annual reduction in sustainment (ST), modernization (FM), and base operating support (BOS) divided by project cost. This is termed the simple payback period in financial language.
- Footprint reduction
  - This is the net reduction in shore footprint quantity as measured in square foot equivalents (SFE).
- Mission criticality
  - This identifies the average mission dependency index (MDI) of the facilities being demolished.
- Utilization improvement
  - This measures the degree of installation capacity utilization improvement in terms of reducing unneeded capacity.

- Condition improvement
  - This notes the average condition rating of the facilities being demolished.
- Facility age reduction
  - This measures the average age from initial construction of the facilities being demolished.

The purpose of this project is to develop a method for identifying the optimal subset of all consolidation projects submitted by the installations. By optimal, we mean that the projects selected, as a portfolio, should be such that collectively they maximize some overall objective function while the total expenditure for all selected projects remains within the available budget.

In FY 2009, CNA developed an optimization model for the Director, Shore Readiness Division (N46), that focused specifically on demolition projects [1]. In that project, our goal was to develop a model that would identify the optimal set of demolition projects that should be funded so as to maximize the net present value (NPV) of savings from the selected projects given the levels of funding available for demolition projects. The model was also capable of determining the optimal set of projects to fund if the objectives were to maximize the total reduction in square feet of excess capacity. From a purely financial viewpoint, the only driver should have been the NPV of savings, but the Navy also wanted to reduce its actual shore footprint by eliminating unneeded capacity.

In that previous effort, we studied the characteristics of the demolition projects submitted by the installations. Included in each project submission was (1) the net reduction in square footage if the demolition project was undertaken and (2) the estimated NPV of savings from the project. If the footprint reduction for the demolished facility was measured in something other than square feet, that measure was only recorded on the project submission and not included in the analysis. In that previous study, the problem was to determine, in some manner, the optimal set of demolition projects to undertake given the available budget. We recognized that we were looking at a traditional "knapsack problem,"[2] where there are two separate objec-

tive functions to consider. The knapsack problem is normally characterized as a maximization, 0 to 1 integer programming problem, where there is a single constraint and the values for the decision variables can only assume the value of 0 or 1 in any solution. If the variable assumes the value of 1, it implies the project is selected for funding; however, if the variable assumes the value of 0, it implies the project was not selected to be funded.

The first objective function used to determine the set of demolition projects to undertake was that of maximizing the total NPV of savings across all projects. The optimization problem solution set consists of those projects that should be selected for funding based on their total NPV of savings. We then allowed the available budget to vary over a range of values to assess how the optimal mix of projects would change for given changes in the funding availability.

The second objective function considered was to maximize the total square footage of excess capacity eliminated over all projects selected for funding. Note there is a positive relationship between the NPV of a project and the net reduction in square footage; projects that yield a large NPV in savings are also likely to eliminate a large amount of excess square footage. However, the choice of demolition projects to fund under the criterion of maximizing excess inventory turned out to be different from the set of projects that had an objective of maximizing the total NPV in savings.

To reconcile the two different project selections in that earlier effort, we combined the two objective criteria using a multi-criteria approach. The two respective criteria were assigned weights (with the weights summing to 1), and the problem was resolved. In that analysis, the weights were allowed to vary, and, in this manner, decision-

2. The traditional knapsack problem is a statistical problem in combinatorial optimization: Given a set of items, each with a weight and a value, we determine the count of each item to include in a collection so that the total weight is less than or equal to a given limit and the total value is as large as possible. It derives its name from the problem faced by someone who is constrained by a fixed-size knapsack and must fill it with the most useful items. This problem often arises in resource allocation with financial constraints.

makers could parametrically determine how the set of projects selected for funding changed as the weights for the two objective functions changed.

Issues

In this current project, the problem structure is identical to that previous effort, except that OPNAV N46 now requests that six decision criteria be considered instead of just two. The problem is similar in that there is a fixed budget available to fund consolidation projects. However, the process to determine which set of consolidation projects to fund so as to maximize the overall objective (that is now an aggregation of six individual criteria) is different. The structure of this new problem is called a multiple criteria knapsack problem. The overall knapsack problem is characterized by there being a single constraint; the constraint in this problem is a limited budget.

To summarize, selecting the set of consolidation projects to fund is an optimization problem whereby the decision-maker wishes to maximize the total value of the projects selected subject to budget restrictions. The difficult part of the problem is in how to construct a function that constitutes the overall value of the selected projects since there are six criteria being used to evaluate projects and these six criteria must all be weighted together to form a single objective function.

Organization of report

This report is organized into eight sections. First, we describe those characteristics of a consolidation project that are attractive from a strategic viewpoint. This gives guidance to installation personnel who develop potential projects. Next, we describe the factors that are used to evaluate projects submitted for review. In these descriptions, we include the required project data inputs, how the factors are calculated, and how each factor is incorporated into the final decision. We next discuss how, for each factor, we transform the observed value for the factor to an index that allows for a common measurement scale for each of the six factors included in the decision-support system. Specific data from 18 submitted projects are presented and the factor

scores are given for each project. We then provide background information on revealed preference and market basket analysis to show how the problem may be cast as a multiple criteria knapsack problem once the Navy has evaluated the other available consolidation projects. This allows each factor to be incorporated into the objective function via a weighting scheme, and selection of the best mix of projects can be made based on the funding available. Lastly, we present our recommendations, discussing how N46 can use the model to develop an optimal set of consolidation projects to fund.

What is a consolidation project?

The Navy programs two different types of facilities projects: military construction projects and special projects. The difference between these two types of projects is related to size. Military construction projects are larger and need congressional budget line item approvals prior to their execution. Special projects are programmed as a lump sum budget item and approval for execution lies within the Navy. There are several kinds of special projects; they are categorized by the preponderance of work type performed. The following is a listing of the different types:

- Repair
- Construction
- Maintenance
- Equipment installation

These work types are funded under the following investment accounts:

- Restoration and modernization (RM)
- Sustainment (ST)
- Demolition (DE)
- New footprint (NF)

A consolidation project can be either military construction or a special project, and any or all of the above work types can be included within its scope; however, the majority of the work is normally demolition.

Purpose of consolidation projects

Consolidation projects are used to relocate personnel and equipment from underutilized and usually deficient facilities to other facilities. Consolidation projects include restoration, modernization, and possibly some new construction to prepare the new space. This is done in order to allow the previously occupied facilities to be demolished.

Development of new consolidation projects is not easy and can be a time-consuming process. There are many possible alternative scopes to select from since there is no single need driving the requirement to focus the project development. Balancing the trade-offs between elimination of underutilized facilities and the provision of new or restored spaces can be challenging. It often requires working with current facility tenants who have had the past luxury of extra space or their own dedicated facilities. An effective consolidation project often requires them to move to much smaller spaces and to share facilities with other organizations. Therefore, development of successful consolidation projects requires significant care and attention to scope content.

Building a successful project

This section provides a general description of the characteristics of a consolidation project that would likely be a strong candidate for funding. That is, the project will yield results that support the Navy's OSF strategy.

It is important to consider each of the six factors that are used to evaluate consolidation projects.

- Financial return on investment (FROI)
  - FROI is the measure of the annual reduction in ST, FM, and BOS costs against the cost of the project. FROI can be measured in two ways. First, it can be measured in terms of simple payback, which refers to the number of years required to recoup, in savings, the amount of money spent on the project. Second, it can be measured in terms of the NPV of the savings less the initial consolidation project cost.

- Footprint reduction
  - Footprint reduction is the net reduction in shore footprint quantity as measured in square foot equivalents (SFE). The newly constructed facilities SFE are subtracted from the sum of the demolished facilities SFE.
- Mission criticality
  - Mission criticality refers to the value of the mission supported by those demolished facilities affected by the consolidation project. It is calculated by averaging their mission dependency index (MDI) ratings.
- Utilization improvement
  - The utilization improvement metric focuses on measuring the degree of installation capacity utilization improvement in terms of reducing unneeded capacity within each facility category code.
- Facility condition
  - Facility condition refers to the physical condition of the facilities demolished by the consolidation project. It is calculated by averaging their facility condition index ratings.
- Facility age
  - Facility age refers to the average actual age of the facilities demolished by the consolidation project. It may be more desirable to eliminate older facilities than newer ones.

Given the above criteria, we prescribe a set of guidelines for developing consolidation projects that yield positive results. Initially, installations should look for facilities that are expensive to maintain and have a significant amount of deferred maintenance. This also coincides with a facility that will contribute to a reduction in shore footprint and total PRV. Facilities that are scheduled for demolition in a consolidation process will most likely be occupied, and, if these facilities are demolished, personnel will need to be relocated. Projects where the amount of additional facility restoration or consolidation

costs needed to relocate the displaced personnel is small are more attractive consolidation projects.

Buildings that are underutilized should also be considered for a consolidation project. Underutilized buildings often have low MDI values and poor condition ratings. These factors help to identify buildings or facilities that are good candidates for inclusion in consolidation projects.

Policy-makers are also interested in reducing the visual footprint of facilities at naval installations. In particular, the Navy is interested in identifying and eliminating those facilities that contribute the most to the overall shore footprint. Therefore, large facilities represent good candidates for inclusion in a consolidation project.

To summarize, attractive consolidation projects should consist of large, underutilized facilities that are high in cost, expensive to operate and maintain, are in poor condition, and have low MDI scores. In addition, attractive consolidation projects should consist of more demolition work and less new construction since the overall goal is to reduce the shore footprint.

Project evaluation factors

In coordination with the OSF task force, we developed six evaluation factors in the cROI programming tool to be used to compare consolidation projects that have been submitted by the Commander, Navy Installations Command (CNIC) regions:

- Financial return on investment (FROI)
- Footprint reduction
- Mission criticality
- Utilization improvement
- Condition improvement
- Facility age improvement

Financial return on investment (FROI)

FROI is a measure that compares the initial cost of a consolidation project with the long-term savings that occur after the project is completed. This calculation creates a metric representing a project's payback period in years. The shorter the payback period, the better the project.

Project data inputs

Current working estimate (CWE) is the total project cost from the project DD Form 1391.

The annual sustainment cost requirements are found in the current Office of the Secretary of Defense (OSD) Facility Sustainment Model (FSM) for each demolished facility. The percentage of the FSM output programmed by the Navy is used to calculate the estimated annual sustainment cost savings for each demolished facility.

The annual facility modernization cost requirements come from the OSD Facility Modernization Model (FMM) for each demolished facility. The percentage of the FMM model output programmed by the Navy is used to calculate the estimated annual modernization savings for each demolished facility.

The annual BOS costs for the base come from the Navy's certified financial reports from the end of the previous fiscal year. The total base PRV supported by Navy operations and maintenance is found in the Internet Navy Facility Asset Data Store (iNFADS). The PRV and size of each facility demolished by the project also comes from iNFADS. Dividing the total base annual BOS costs by the total base PRV creates a BOS$/PRV$ factor. This factor is then multiplied by the demolished facility's PRV. This yields an estimated annual BOS cost savings for the demolished facility.

Factor calculations

The sum of the estimated annual ST, FM, and BOS savings for all the demolished facilities is divided into the project's CWE to determine the project's FROI in years.

Results measure

The FROI is measured in years.

Footprint reduction

Footprint reduction is a measure of the size of the facilities that are demolished by a consolidation project, reduced by the size of any facilities built by the project. The larger the amount of facilities eliminated, the better the project.

Project data inputs

The total square feet (SF) for base facilities measured in SF and the total PRV for all base facilities measured in SF are extracted from iNFADS. This total PRV amount divided by this total SF creates a square foot equivalent (SFE) conversion factor for that specific base.

The total area for all facilities, by unit of measure (UOM), demolished by the project, and the total PRV for these facilities also comes from iNFADS.

The SFE conversion factor is multiplied by the PRV of the demolished facilities to obtain an SFE number. These individual amounts measured in SFE are added together with the facilities measured in SF to provide a total SFE reduction quantity. The total SFE for newly constructed facilities comes from the project DD Form 1391. The input includes these newly constructed facilities, but not renovated ones.

Factor calculations

To obtain the net footprint reduction for the project, the total amount of new facilities built (if any) is calculated in SFE and subtracted from the total amount of any facilities demolished.

The amount of facilities demolished is calculated by adding the SF of any demolished facility, measured in SF, to the SFE of any demolished facility, measured in units other than SF. The SFE is calculated by multiplying the demolished facility's PRV by the base's SFE conversion factor.

The amount of new facilities built is calculated by adding the SF of any new facility, measured in SF, to the SFE of any new facility, measured in units other than SF. SFE is calculated by multiplying the new facility's PRV by the base's SFE conversion factor.

Results measure

The footprint reduction factor is measured in SFE.

Mission criticality

Mission criticality is a measure of how dependent base missions are on the facilities being demolished by the consolidation project. The less critical the facilities are, the better the project.

Mission criticality uses the MDI rating, which is a number between 1 and 100 that is assigned to each facility by base personnel and

approved by the Installation Commander. The MDI reflects the importance of the facility to the base's mission performance.

Project data inputs

The MDI rating and PRV amount for each demolished facility comes from iNFADS.

Factor calculations

This factor is calculated by multiplying each demolished facility's MDI rating by its PRV amount. These are added together and the total is divided by the total PRV for all the demolished facilities in order to calculate a PRV-weighted average MDI rating for the project.

Results measure

Mission criticality is a number from 1 to 100 that represents the PRV-weighted average MDI for the demolished facilities.

Utilization improvement

The utilization improvement is a measure of the portion of a facility type's "available" facilities at a base that are demolished by the consolidation project. The larger the elimination, the better the project.

Available facility amounts are determined in the Navy's facility planning process; for each facility category code (CCN) at a base, the total amount of facility assets available is compared with the total requirement for these assets at the base. If the available assets exceed the requirement, then the difference is the available facility amount. This is measured in the UOM for that CCN. This is an interim metric pending implementation of the new Naval Facilities Engineering Command (NAVFAC) utilization factor.

Project data inputs

The size, CCN, and PRV for each facility demolished by the project is obtained from iNFADS.

The amount of "available" facilities at the project's base for each of the project's CCNs is obtained from iNFADS.

Factor calculations

The facilities being demolished are grouped by CCN. The total demolished size for that CCN is calculated by adding the SF or SFE for each facility. The total demolished size is divided by the amount of available facilities for that CCN in order to calculate a ratio that represents the portion of that CCN's available facilities that are eliminated by the project.

The individual CCN ratios are each weighted by the project's total PRV for that CCN. These weighted ratios are added together and divided by the total project PRV for demolished facilities in order to determine a PRV-weighted average of available facility reduction.

Results measure

The utilization improvement factor is the PRV-weighted average percentage amount of available facility reduction.

Facility condition improvement

The facility condition improvement factor is a measure of the current condition of the facilities being demolished by the consolidation project. The poorer the condition of the eliminated facilities, the better the project.

The facility condition improvement factor, which is a number between 1 and 100, uses the facility condition index rating for each facility.

Project data inputs

The facility condition index rating and PRV for each demolished facility are obtained from iNFADS.

Factor calculations

The condition rating for each demolished facility is multiplied by the facility's PRV. These are added and the total is divided by the total PRV of all the demolished facilities in order to determine a PRV-weighted condition rating.

Results measure

The facility condition improvement is a number from 1 to 100 that represents a PRV-weighted average condition index for the demolished facilities.

Facility age improvement

The facility age improvement is a measure, based on the original construction date, of the age of the facilities being demolished by the consolidation project. The older the demolished facilities are, the better the project.

Project data inputs

The original year of construction and PRV for each demolished facility are found in iNFADS.

Factor calculations

For each demolished facility, the age is calculated by subtracting the original construction date from the current year; this age is multiplied by the facility's PRV. These are added together and divided by the total PRV for all demolished facilities in order to determine a PRV-weighted average facility age for the project.

Results measure

The facility age improvement factor is the PRV-weighted average age of the facilities demolished by the project.

Normal distribution conversion

As discussed in the previous section, there are six different metrics that define each of the projects. These metrics are measured in a variety of units and the range of each metric is vastly different. Therefore, to calculate a single project score, each metric must be standardized to the same scale. In this section, we describe how we do this.

Theory

To standardize, we convert each metric to an index number by assuming a distribution for each of the metrics. We assume that the mission criticality, utilization improvement, condition improvement, and facility age improvement metrics are from a normal distribution and that the footprint reduction and FROI metrics are log normally distributed. Assuming that the footprint reduction and FROI metrics are log normally distributed is equivalent to assuming that the natural log of each metric is normally distributed. So, from this point forward we do not differentiate these metrics from the other four. We made these distributional assumptions after analyzing the means, standard deviation, ranges, and histograms of each metric.

After calculating the metric value for each project, we found the index number by evaluating the baseline cumulative normal distribution at the metric value. This methodology makes intuitive sense since each index number is the probability that the metric is greater than another random metric value. This method is also very convenient because a normal distribution has two parameters, mean and standard deviation, that are simple to calculate. Additionally, a normal distribution has a range that covers all real numbers, which makes this methodology compatable with the introduction of new projects. Sometimes, new projects have metrics that are vastly different from previous project submissions and fall outside the current standardization range. The more common linear scaling transformation tech-

niques do not easily accommodate out-of-range values. The full range of the normal distribution allows the metrics to be converted to index numbers for any possible new project.

In using this technique, we gain a flexible, intuitive, and computationally simple way of combining multiple metrics into a single project score. In summary, there are three main advantages to assuming each metric is distributed normally:

- The method is flexible (or robust to the introduction of new projects). Normal distributions do not have minimum or maximum values, so all potential projects and their metric values can be evaluated.
- The method produces index scores that have an intuitive analytical interpretation. The index score is the probability that another project will have a metric lower than the current project. For example, an index score of 0.7500 implies that there is a 75-percent chance of another metric being smaller than the current project.
- This method is computationally simple; it is easy to fit a normal distribution to the data. One need only calculate a mean and standard deviation of the previous project metrics, and then use the normal distribution functions that are built into most software packages to calculate the index score.

Application

We used the results from 210 programmed FY 2009 and FY 2010 demolition projects to calculate the baseline normal distribution for each metric. We calculated the new metrics for each of the previous demolition projects and used these values to generate a sample mean and standard deviation for each measure to use as the parameters for establishing the baseline normal distributions. Since there are six metrics, there are six different baseline normal distributions. The current consolidation metrics are then evaluated with their baseline

distributions. Table 1 provides a sample mean, standard deviation, and coefficient of variability for each metric.

Table 1. Normalization table mean, standard deviation, and variability results

Metric	Measure	Mean	Standard deviation	Variability
FROI	Natural log	1.560	1.022	0.655
Footprint	Natural log	9.330	1.718	0.184
Mission	Weighted average	41.621	25.400	0.610
Utilization	Weighted average	0.326	0.344	1.055
Condition	Weighted average	64.838	18.523	0.286
Age	Weighted average	57.385	20.550	0.358

The coefficient of variability is equal to the standard deviation/mean and reflects the degree of variation within a metric distribution. A value higher than 1.000 indicates a high degree of variance within the distribution. In this case, only utilization displays a variability coefficient higher than 1.000; therefore, the consolidated score result is more sensitive to equal swings in utilization value when compared with the other metrics.

Metric conversion example

Here we give a simple numerical example of how the metric is converted into an index number. Assume that the weighted average facility age metric for a consolidation project equals 59.5 years. Assume also that the average of the facility age metrics for all the baseline demolition projects is 57.4 years and that the standard deviation for this sample of metrics is 20.6. The index value for the consolidation project equals the cumulative distribution of a normal distribution with mean 57.4 and standard deviation 20.6 evaluated at 59.5. This equals 0.541, which means that if one were to pick another facility age metric at random, there is a 54-percent chance that the random number would be lower than 59.5 years. Therefore, by this methodology, the metric is transformed into a standard index value that shows the size of the metric in probability terms.

Note that since the mean for both FROI and footprint reduction were both close to zero, as shown in figures 1 and 2, we had to utilize the natural log of the raw score to achieve a better normalization curve.

Figure 1. Normalization table FROI distribution

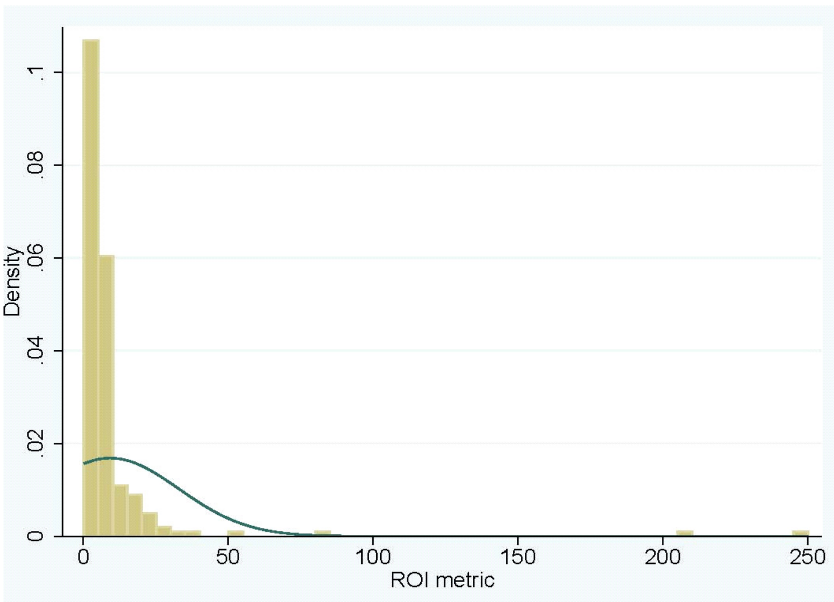
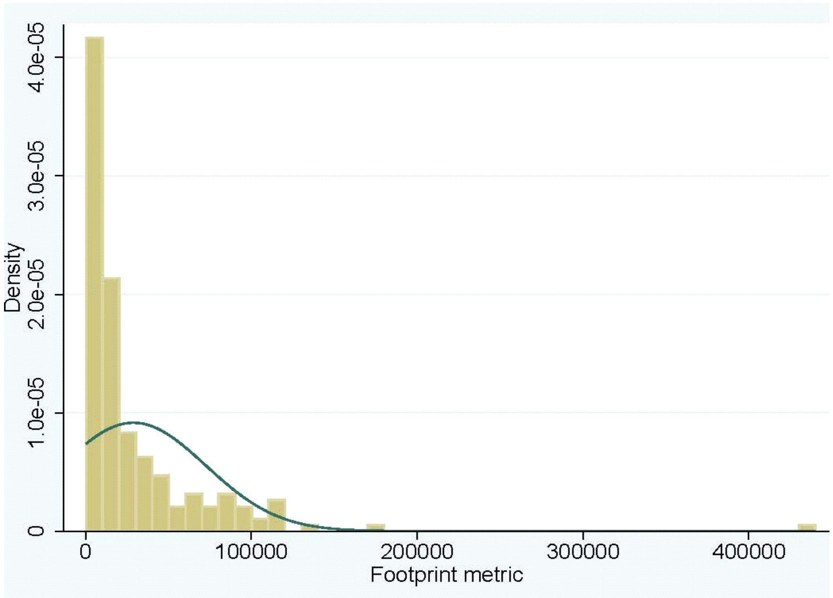


Figure 2. Normalization table footprint reduction distribution



When we use the natural log function to convert the raw scores, a value less than one will result in a negative result. This only happens with FROI as several projects had a payback of less than a year. The negative scores do not bother the normalization because we calculate the area under the curve to obtain the result.

Figures 3 through 8 provide distribution histograms for each of the metrics within the sample set.

Figure 3. Normalization table FROI natural log distribution

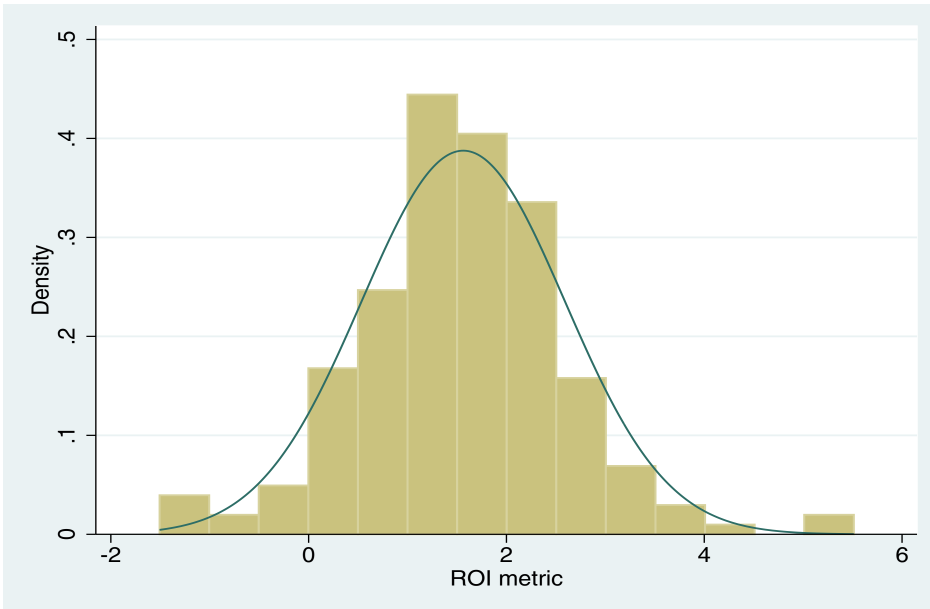


Figure 4. Normalization table footprint reduction natural log distribution

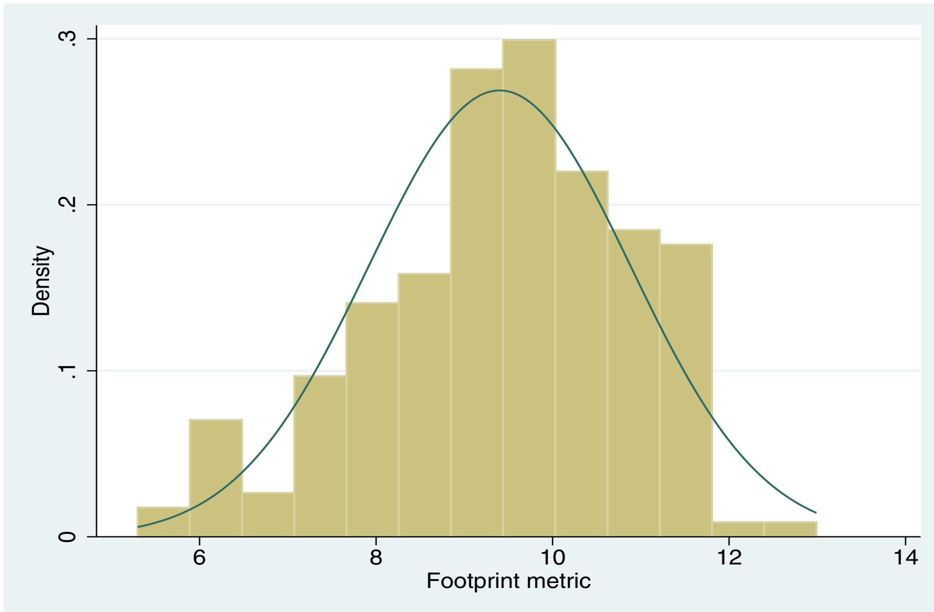


Figure 5. Normalization table MDI distribution

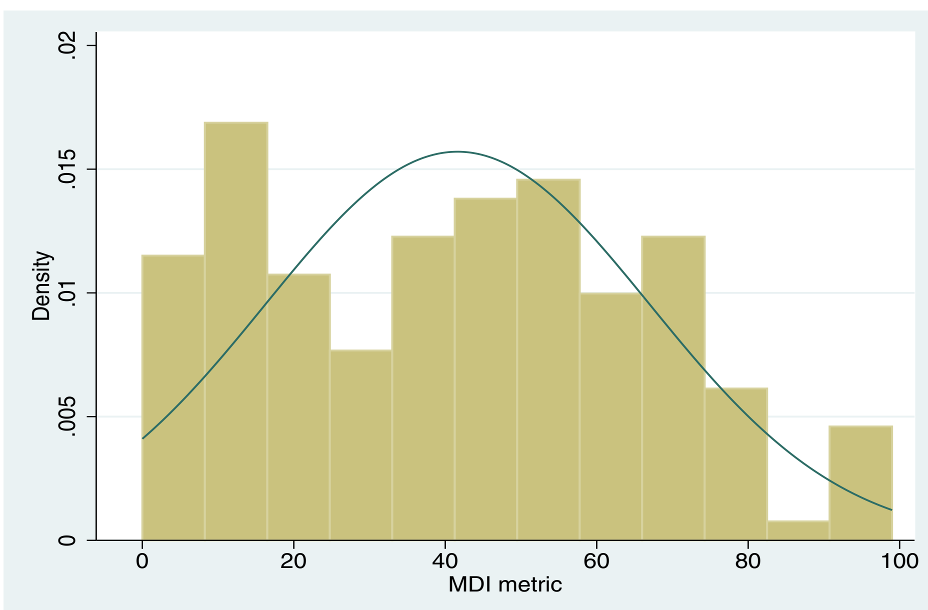


Figure 6. Normalization table utilization improvement distribution

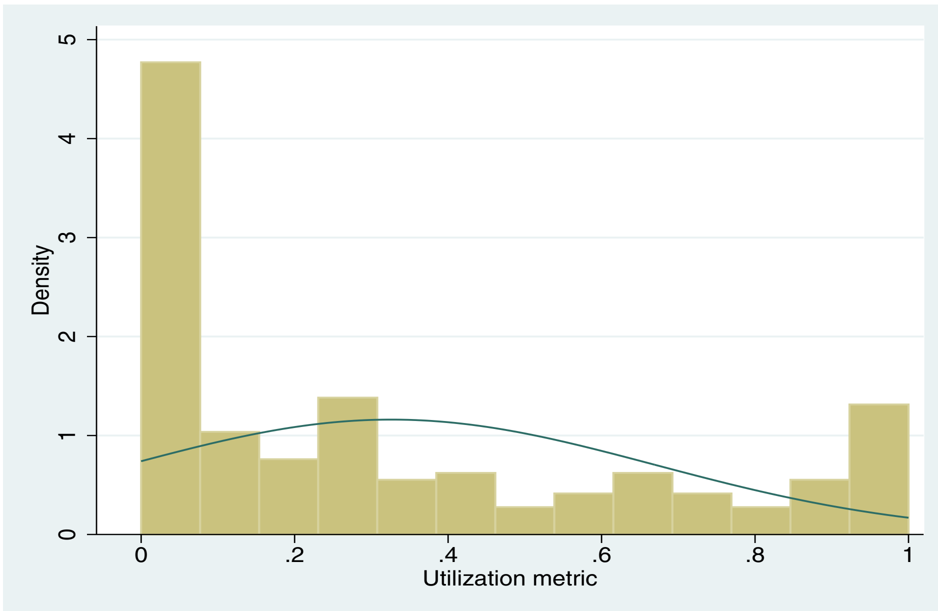


Figure 7. Normalization table condition rating distribution

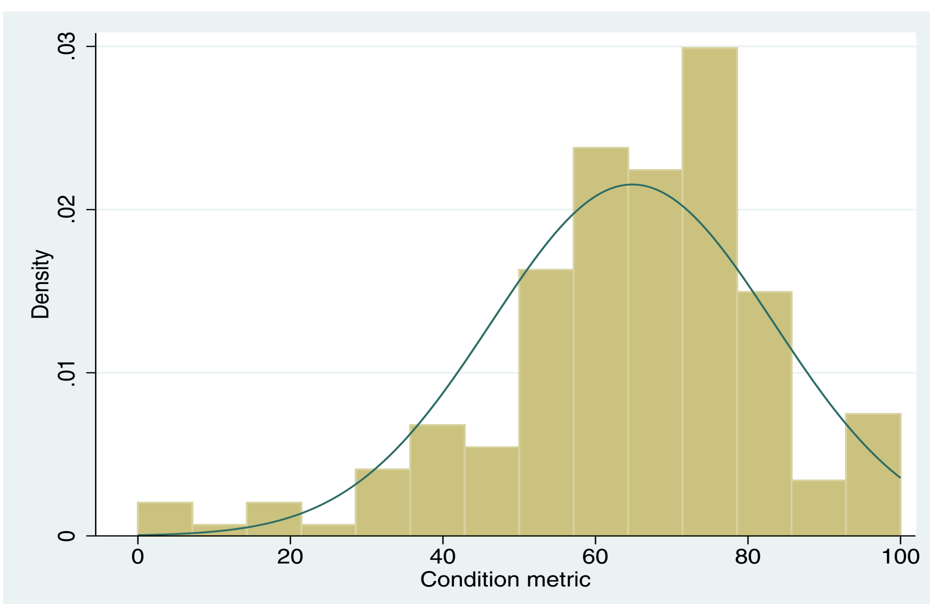
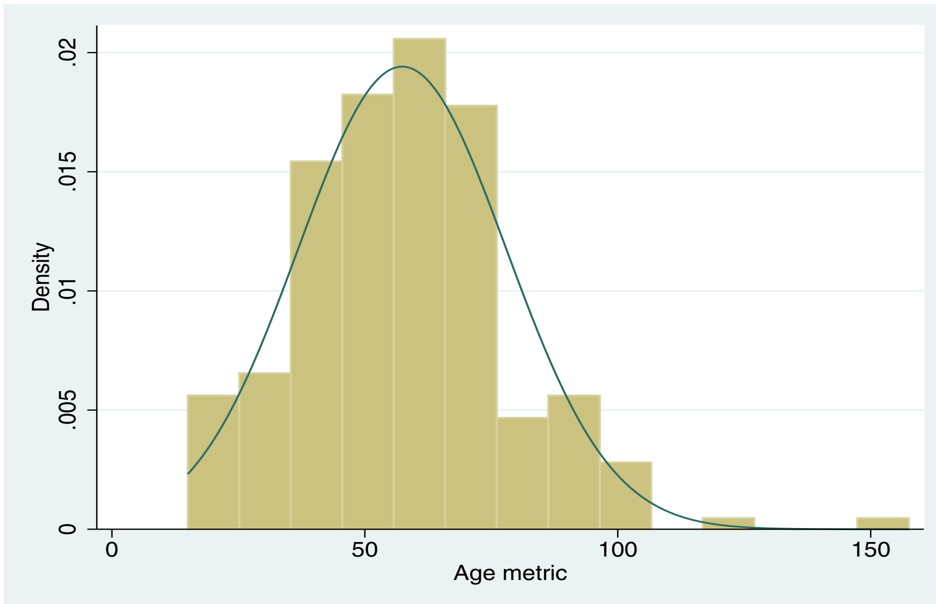


Figure 8. Normalization table facility age distribution



Using these normalization curves allows us to convert the raw scores into compatable normalized scores between zero and one. Since we want the measure of positiveness to be 1.0, we take the inverse area measure for FROI, mission dependency, and condition rating so that they are consistent with the other benefit measures. We can then consolidate these measures into one overall score with user-provided factor weights.

The distributional assumptions and baseline data show one limitation of this approach. The mission and condition metrics are necessarily constrained to values between 0 and 100, and the utilization metric is constrained between 0 and 1. As previously mentioned, the normal distribution allows for a full range of values, so the actual range of the metrics and the normal distribution range do not match exactly. However, one feature of the normal distribution is that the probability of any value more than three standard deviations away from the mean is so small as to be trivial for practical purposes. The limitation of our method is that fitting a normal distribution to these baseline metrics produces distributions where there is some non-trivial proba-

bility outside the range of the metrics. For example, the baseline mission metric has a mean of 41.6 and standard deviation 25.4. Based on these values, the normal distribution assumptions places non-trivial probability on the range [-34.6, 117.8]. Since the lowest raw value possible is zero, the net effect is a reduction of the benefit score range from [0, 1] to [0, 0.9494]. If the mean becomes higher and/or the standard deviation tighter with the addition of new projects to the normalization table, this benefit score truncation effect goes away.

This limitation could be relaxed by assuming a different distribution for these metrics. However, we feel that the normal distribution assumption is the practical choice in this case because choosing another distribution with truncation would greatly complicate the normalization process without providing many benefits. For the condition and mission metrics, three standard deviations away from the mean does not extend very far beyond the [0, 100] range. Therefore, a different distributional assumption would not drastically change any results.

Programming tool structure

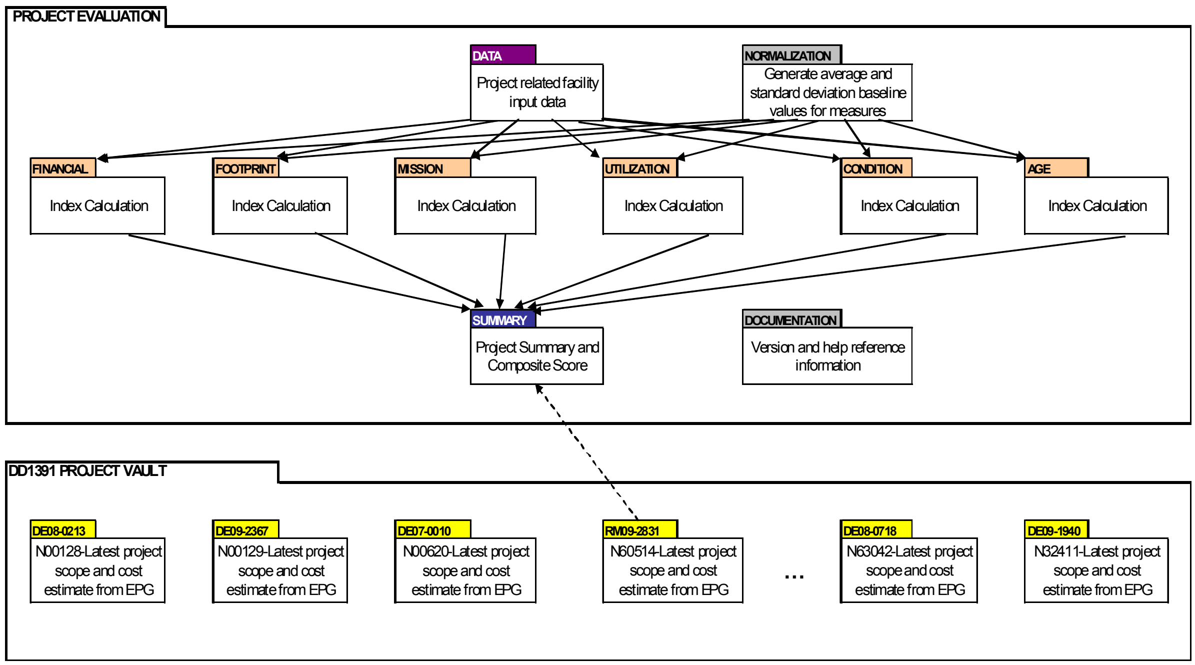
Each consolidation project candidate should be evaluated with a separate algorithm/worksheet so that it can be linked to the project DD Form 1391 scope of work and cost estimate. In addition, each metric should be calculated on a separate worksheet and linked to an overall summary worksheet. This will help provide the programming tool with the following attributes: clarity of metric evaluation, completeness in necessary evaluation data, and simplicity in composite score calculation.

Model framework

We use Microsoft Excel workbooks to structure the programming tool and standardize the formatting as much as possible in order to minimize adjustments to the worksheet. Figure 9 provides a concept flow

diagram of how the different elements of the project evaluation link together.

Figure 9. Project worksheet layout



The necessary facility evaluation information is extracted from the project data worksheet, which feeds the six evaluation factor worksheets. The individual benefit scores are automatically transferred to the summary sheet, which applies the user-supplied factor weighting in order to generate a ROI composite score. A hyperlink on the summary sheet quickly opens the project DD Form 1391 scope of work for reference. The normalization worksheet provides the mean and standard deviation from previous projects to each of the factor sheets in order to index the raw factor benefit scores into an index that is compatible with the other factor indexes. Finally, a documentation worksheet contains the model version and information sources.

Worksheets

To evaluate the model we chose special project RM09-2831, “Consolidation to M207 and demolition,” which was submitted by Naval Station Guantanamo Bay, Cuba. The first worksheet in the model is the summary worksheet. Figure 10 shows an example of this sheet.

Figure 10. cROI programming tool—project summary sheet

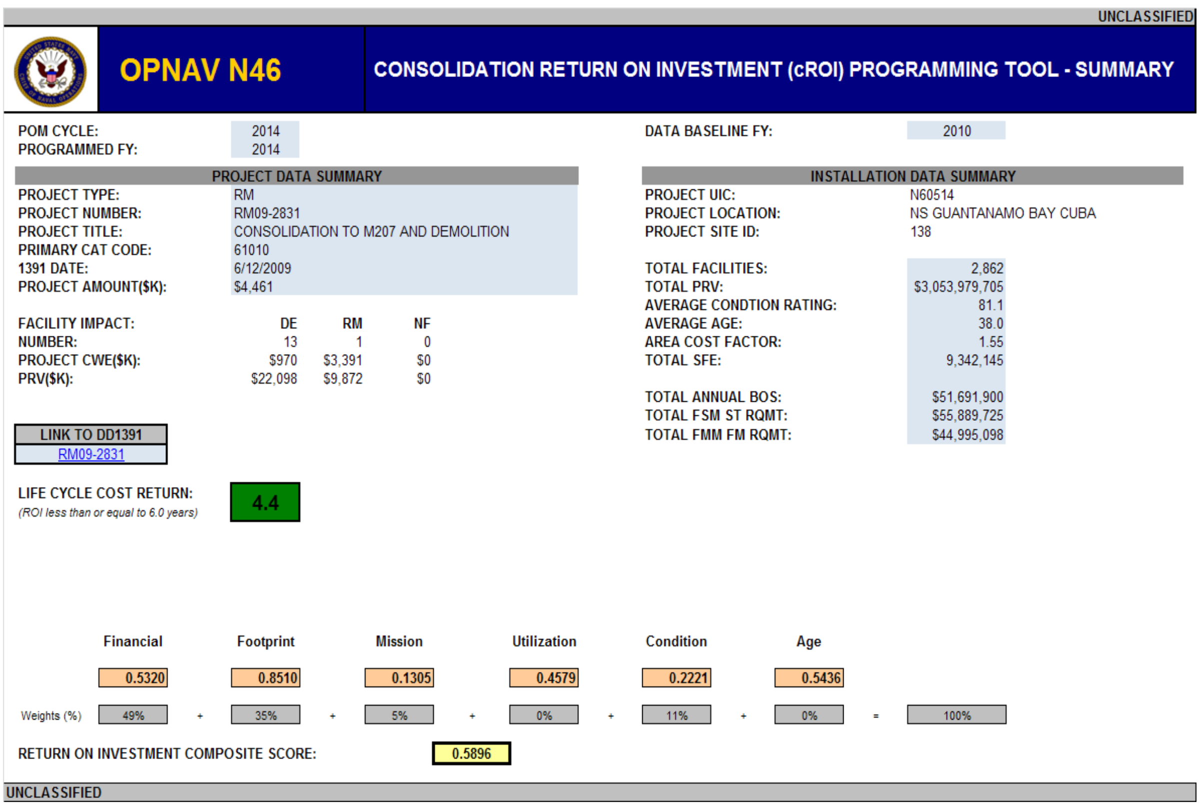


Figure 11 shows the first factor benefit score evaluation: FROI.

Figure 11. cROI programming tool—project financial sheet

UNCLASSIFIED

OPNAV N46 | **CONSOLIDATION RETURN ON INVESTMENT (cROI) PROGRAMMING TOOL - FINANCIAL**

INPUTS

TYPE	FAC ID	FAC NO	ANNUAL ST	ANNUAL FM	ANNUAL BOS	ANNUAL ST (NF)	ANNUAL FM (NF)	ANNUAL BOS (NF)
DE	NFA100001032125	1111	$34,874	$11,498	$19,530			
DE	NFA100001032919	AV79	$12,449	$8,903	$18,110			
DE	NFA100001045754	191	$2,054	$1,535	$3,093			
DE	NFA100001041080	2164	$23,287	$25,960	$48,179			
DE	NFA100001040376	M129	$17,294	$18,456	$33,349			
DE	NFA100001039039	2132	$8,299	$5,935	$12,074			
DE	NFA100001038316	2022	$6,640	$4,725	$9,998			
DE	NFA100001038110	M222	$11,710	$12,221	$26,246			
DE	NFA100001045763	190	$2,054	$1,535	$3,093			
DE	NFA100001030733	865	$9,959	$7,122	$14,488			
DE	NFA100001030706	AV81	$98,275	$57,958	$116,415			
DE	NFA100001038049	M202	$14,180	$11,620	$22,829			
DE	NFA100001031867	760	$114,846	$111,552	$266,382			

CALCULATIONS

		Totals (DE):	$355,922		$279,020		$593,787		
		Less totals (NF):	$0		$0		$0		Discount Rate
		Totals:	$355,922		$279,020		$593,787		3.1%
		Program level:	80%		50%		100%		
	CWE	Annual reduction:	$284,738		$139,510		$593,787	=	$1,018,035
NPV (5 years) =	-$4,461,000	+	$1,300,301	+	$637,094	+	$2,711,623	=	$188,018

RESULTS

Financial ROI	4.4	years	NATURAL LOG
Cumulative Probability	0.4680		1.477

FINANCIAL BENEFIT SCORE: 0.5320

LOWER IS BETTER

NORMAL DISTRIBUTION INDEXING

Mean: 1.560

Standard Deviation: 1.022

UNCLASSIFIED

Each of the six factor worksheets is divided into inputs, calculations, and results. This sheet calculates both the five-year NPV and the simple return on investment ratio in terms of years to investment recovery. The normalization chart is a visual representation of where the project's FROI value falls in comparison with the mean for past projects included in the normalization table. In this case, a lower value (i.e., shorter ROI) is better. The shaded area is equal to the financial benefit score value. The total area under the normalization curve is equal to one.

The next factor benefit calculation relates to shore footprint reduction. Figure 12 shows an example of this worksheet.

Figure 12. cROI programming tool—project footprint reduction

UNCLASSIFIED

OPNAV N46 | **CONSOLIDATION RETURN ON INVESTMENT (cROI) PROGRAMMING TOOL - FOOTPRINT**

INPUTS

TYPE	FAC ID	FAC NO	PRV	AREA (DE)	AREA (NF)	UOM	SFE CONV	SFE (DE)	SFE (NF)
DE	NFA100001032125	1111	$726,820	10,516		SF	1.00	10,516	
DE	NFA100001032919	AV79	$673,999	1,440		SF	1.00	1,440	
DE	NFA100001045754	191	$115,120	594		SF	1.00	594	
DE	NFA100001041080	2164	$1,793,044	4,144		SF	1.00	4,144	
DE	NFA100001040376	M129	$1,241,135	3,344		SF	1.00	3,344	
DE	NFA100001039039	2132	$449,333	960		SF	1.00	960	
DE	NFA100001038316	2022	$372,104	1,920		SF	1.00	1,920	
DE	NFA100001038110	M222	$976,772	2,142		SF	1.00	2,142	
DE	NFA100001045763	190	$115,120	594		SF	1.00	594	
DE	NFA100001030733	865	$539,199	1,152		SF	1.00	1,152	
DE	NFA100001030706	AV81	$4,332,510	15,549		SF	1.00	15,549	
DE	NFA100001038049	M202	$849,623	2,856		SF	1.00	2,856	
DE	NFA100001031867	760	$9,913,700	22,198		SF	1.00	22,198	

CALCULATIONS	Sum of DE SFE	67,409	SFE
	Less sum of NF SFE	0	SFE
RESULTS	**Net footprint reduction**	67,409	SFE
FOOTPRINT BENEFIT SCORE: 0.8510		NATURAL LOG 11.119	

NORMAL DISTRIBUTION INDEXING

Mean: 9.330

Standard Deviation: 1.718

UNCLASSIFIED

In the past, structure and utility demolitions were not given credit for removal since they were not measured in SF. To address this shortcoming, we introduce the concept of square feet equivalents (SFE). Facilities measured in SF at the host installation have their total SF divided into that year's PRV for those facilities. This conversion ratio is multiplied by the other UOM total PRVs in order to calculate the SFE for each. This allows us to sum the footprint reduction area for all demolished facilities into a total SFE number for evaluation.

The next factor worksheet uses the average (weighted by PRV) MDI to assess the mission importance of the facilities being demolished. Figure 13 provides an example of this worksheet.

Figure 13. cROI programming tool—mission importance

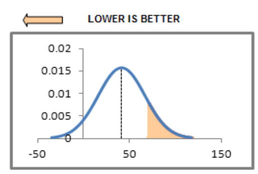
UNCLASSIFIED

OPNAV N46

CONSOLIDATION RETURN ON INVESTMENT (cROI) PROGRAMMING TOOL - MISSION

INPUTS

TYPE	FAC ID	FAC NO	PRV	MDI
DE	NFA100001032125	1111	$726,820	55
DE	NFA100001032919	AV79	$673,999	70
DE	NFA100001045754	191	$115,120	11
DE	NFA100001041080	2164	$1,793,044	72
DE	NFA100001040376	M129	$1,241,135	36
DE	NFA100001039039	2132	$449,333	17
DE	NFA100001038316	2022	$372,104	0
DE	NFA100001038110	M222	$976,772	50
DE	NFA100001045763	190	$115,120	11
DE	NFA100001030733	865	$539,199	17
DE	NFA100001030706	AV81	$4,332,510	50
DE	NFA100001038049	M202	$849,623	16
DE	NFA100001031867	760	$9,913,700	100



CALCULATIONS — Totals: 22,098,479 — Sum Product PRV and MDI: 1,550,700,810

PRV Weighted DE Average Mission Score: 70

RESULTS — Cumulative Probability: 0.8695

NORMAL DISTRIBUTION INDEXING

Mean: 41.6

Standard Deviation: 25.4

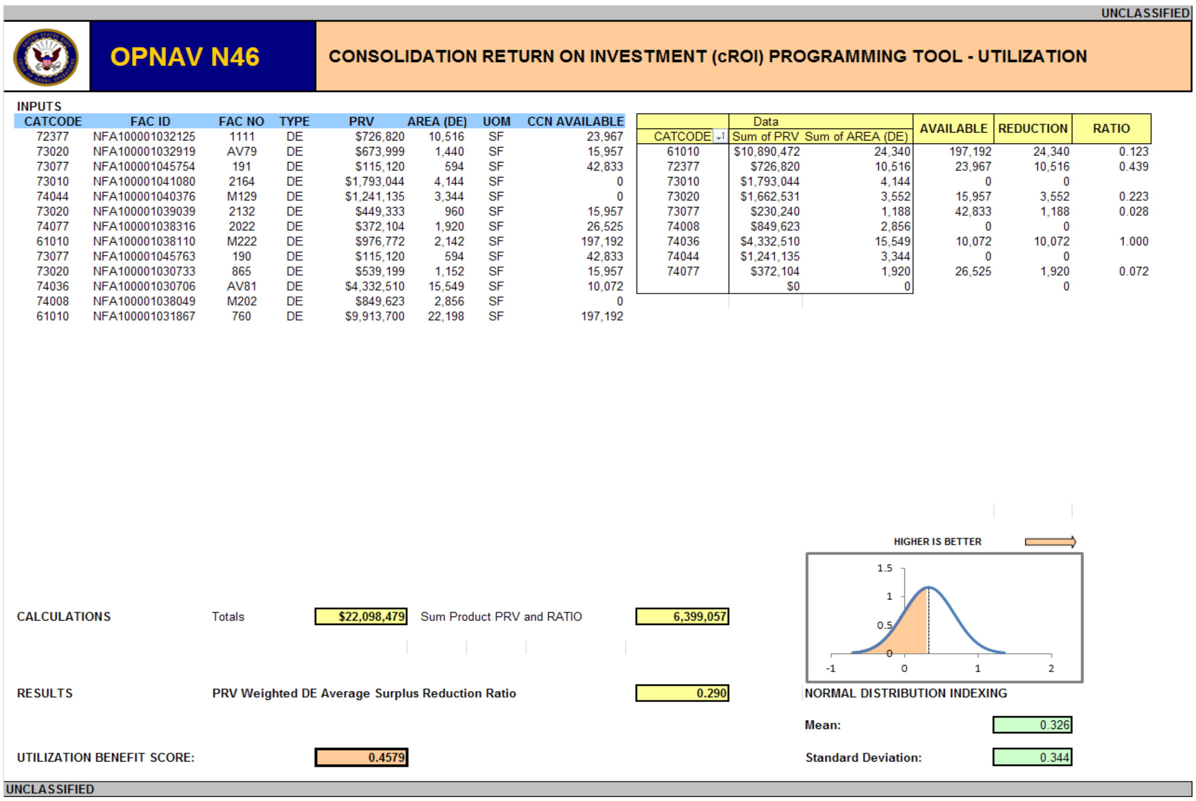
MISSION BENEFIT SCORE: 0.1305

UNCLASSIFIED

The next factor benefit rating sheet, shown in figure 14, reflects a more complicated calculation process. In this case, we need to evalu-

ate the utilization improvement on the facility CCNs rather than on individual facilities.

Figure 14. cROI programming tool—utilization improvement



UNCLASSIFIED

OPNAV N46

CONSOLIDATION RETURN ON INVESTMENT (cROI) PROGRAMMING TOOL - UTILIZATION

INPUTS

CATCODE	FAC ID	FAC NO	TYPE	PRV	AREA (DE)	UOM	CCN AVAILABLE
72377	NFA100001032125	1111	DE	$726,820	10,516	SF	23,967
73020	NFA100001032919	AV79	DE	$673,999	1,440	SF	15,957
73077	NFA100001045754	191	DE	$115,120	594	SF	42,833
73010	NFA100001041080	2164	DE	$1,793,044	4,144	SF	0
74044	NFA100001040376	M129	DE	$1,241,135	3,344	SF	0
73020	NFA100001039039	2132	DE	$449,333	960	SF	15,957
74077	NFA100001038316	2022	DE	$372,104	1,920	SF	26,525
61010	NFA100001038110	M222	DE	$976,772	2,142	SF	197,192
73077	NFA100001045763	190	DE	$115,120	594	SF	42,833
73020	NFA100001030733	865	DE	$539,199	1,152	SF	15,957
74036	NFA100001030706	AV81	DE	$4,332,510	15,549	SF	10,072
74008	NFA100001038049	M202	DE	$849,623	2,856	SF	0
61010	NFA100001031867	760	DE	$9,913,700	22,198	SF	197,192

	Data		AVAILABLE	REDUCTION	RATIO
CATCODE	Sum of PRV	Sum of AREA (DE)			
61010	$10,890,472	24,340	197,192	24,340	0.123
72377	$726,820	10,516	23,967	10,516	0.439
73010	$1,793,044	4,144	0	0	
73020	$1,662,531	3,552	15,957	3,552	0.223
73077	$230,240	1,188	42,833	1,188	0.028
74008	$849,623	2,856	0	0	
74036	$4,332,510	15,549	10,072	10,072	1.000
74044	$1,241,135	3,344	0	0	
74077	$372,104	1,920	26,525	1,920	0.072
	$0	0		0	

CALCULATIONS Totals $22,098,479 Sum Product PRV and RATIO 6,399,057

RESULTS PRV Weighted DE Average Surplus Reduction Ratio 0.290

UTILIZATION BENEFIT SCORE: 0.4579

NORMAL DISTRIBUTION INDEXING

Mean: 0.326

Standard Deviation: 0.344

UNCLASSIFIED

The demolished facilities have to be organized by CCNs and summed in order to compare with the amount of available space within that CCN at that installation. The raw score is a percentage of total availability within that CCN reduced by the total demolished available footprint. This PRV weighted reduction percentage is then converted to a utilization benefit score. We note that NAVFAC is currently developing a new approach for measuring facility utilization, so this metric is considered temporary until the Navy selects a different methodology.

The next factor worksheet calculates the facility condition rating weighted by PRV. This is one of the more straightforward calculations; it provides insight into the condition of the demolished facilities prior to disposal. Figure 15 provides an example of this worksheet.

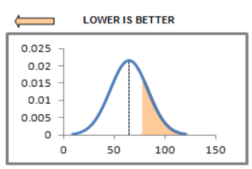
Figure 15. cROI programming tool—condition assessment

UNCLASSIFIED

OPNAV N46 | **CONSOLIDATION RETURN ON INVESTMENT (cROI) PROGRAMMING TOOL - CONDITION**

INPUTS

TYPE	FAC ID	FAC NO	PRV	CND SCORE
DE	NFA100001032125	1111	$726,820	67.0
DE	NFA100001032919	AV79	$673,999	62.0
DE	NFA100001045754	191	$115,120	100.0
DE	NFA100001041080	2164	$1,793,044	81.0
DE	NFA100001040376	M129	$1,241,135	66.0
DE	NFA100001039039	2132	$449,333	59.0
DE	NFA100001038316	2022	$372,104	70.0
DE	NFA100001038110	M222	$976,772	61.0
DE	NFA100001045763	190	$115,120	100.0
DE	NFA100001030733	865	$539,199	54.0
DE	NFA100001030706	AV81	$4,332,510	70.0
DE	NFA100001038049	M202	$849,623	69.0
DE	NFA100001031867	760	$9,913,700	91.0



CALCULATIONS	Totals	22,098,479	Sum Product PRV and CND	1,745,964,504
		PRV Weighted DE Average Condition Score		79.0
RESULTS		Cumulative Probability		0.7779
CONDITION BENEFIT SCORE:		0.2221		

NORMAL DISTRIBUTION INDEXING

Mean: 64.8

Standard Deviation: 18.5

UNCLASSIFIED

The final factor evaluation worksheet, which is shown in figure 16, provides the average age (weighted by PRV) from initial construction for the demolished facilities.

Figure 16. cROI programming tool—age

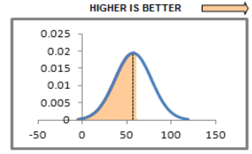
UNCLASSIFIED

OPNAV N46 — **CONSOLIDATION RETURN ON INVESTMENT (cROI) PROGRAMMING TOOL - AGE**

INPUTS

TYPE	FAC ID	FAC NO	PRV	AGE
DE	NFA100001032125	1111	$726,820	56
DE	NFA100001032919	AV79	$673,999	68
DE	NFA100001045754	191	$115,120	67
DE	NFA100001041080	2164	$1,793,044	19
DE	NFA100001040376	M129	$1,241,135	24
DE	NFA100001039039	2132	$449,333	28
DE	NFA100001038316	2022	$372,104	38
DE	NFA100001038110	M222	$976,772	69
DE	NFA100001045763	190	$115,120	67
DE	NFA100001030733	865	$539,199	67
DE	NFA100001030706	AV81	$4,332,510	69
DE	NFA100001038049	M202	$849,623	69
DE	NFA100001031867	760	$9,913,700	67

HIGHER IS BETTER



CALCULATIONS — Totals: 22,098,479 — Sum Product PRV and AGE: 1,317,844,962

RESULTS — PRV Weighted DE Average Age: 59.6 Years

NORMAL DISTRIBUTION INDEXING

Mean: 57.4

Standard Deviation: 20.5

AGE BENEFIT SCORE: 0.5436

UNCLASSIFIED

The next worksheet contains the facility data that were used as inputs for the factor benefit worksheets. Figure 17 provides an example of

this worksheet. It lists all facilities affected by the consolidation project and captures the relevant information for the workbook.

Figure 17. cROI programming tool—facilities data file

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OPNAV N46

CONSOLIDATION RETURN ON INVESTMENT (cROI) PROGRAMMING TOOL - DATA

UNIT PROJECT NUMBER	FUND TYPE	FY	RPSUID	AUIC	ACTIVITY NAME	FACILITY ID	FACILITY NUMBER	FACILITY NAME	PRIMARY CCN	SHORE CAPABILITY AREA	PRV	UOM	QUANTITY	SFE FACTOR	CCN SURPLUS	WORK TYPE	FAC NF CWE ($K)	FAC RM CWE ($K)	FAC DE CWE ($K)	FAC NF UOM	FAC RM UOM	FAC DE UOM	FSM REQ	FMM REQ	BOS REQ	MDI	CND	CFG	CAP	YEAR BUILT	AGE
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001032125	1111	BOQ STORAGE BUILDING	72377	SAILOR AND FAMILY SUPPORT	$726,820	SF	10,516	1.00	23,967	DE	$0	$0	$32	0	0	10,516	$34,874	$11,498	$19,530	55	67	100	100	1954	56
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001032919	AV79	SECURITY DET. AUGMENT BLDG.	73020	BASE SUPPORT	$673,999	SF	1,440	1.00	15,957	DE	$0	$0	$30	0	0	1,440	$12,449	$8,903	$18,110	70	62	71	89	1942	68
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001045754	191	GENERAL PURPOSE WH MA191	73077	BASE SUPPORT	$115,120	SF	594	1.00	42,833	DE	$0	$0	$5	0	0	594	$2,054	$1,535	$3,093	11	100	100	100	1943	67
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001041080	2164	FIRE DEPT ADMIN / RED CROSS	73010	BASE SUPPORT	$1,793,044	SF	4,144	1.00	0	DE	$0	$0	$79	0	0	4,144	$23,287	$25,960	$48,179	72	81	16	93	1991	19
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001040376	M129	FITNESS CENTER	74044	SAILOR AND FAMILY SUPPORT	$1,241,135	SF	3,344	1.00	0	DE	$0	$0	$54	0	0	3,344	$17,294	$18,456	$33,349	36	66	64	37	1986	24
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001039039	2132	SECURITY DET. ADMIN.	73020	BASE SUPPORT	$449,333	SF	960	1.00	15,957	DE	$0	$0	$20	0	0	960	$8,299	$5,935	$12,074	17	59	100	89	1982	28
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001038316	2022	STORAGE BUILDING	74077	SAILOR AND FAMILY SUPPORT	$372,104	SF	1,920	1.00	26,525	DE	$0	$0	$16	0	0	1,920	$6,640	$4,725	$9,998	0	70	100	100	1972	38
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001038110	M222	PENTAD OPERATIONS	61010	BASE SUPPORT	$976,772	SF	2,142	1.00	197,192	DE	$0	$0	$43	0	0	2,142	$11,710	$12,221	$26,246	50	61	100	100	1941	69
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001045763	190	GENERAL PURPOSE WH MA190	73077	BASE SUPPORT	$115,120	SF	594	1.00	42,833	DE	$0	$0	$5	0	0	594	$2,054	$1,535	$3,093	11	100	100	100	1943	67
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001030733	865	SECURITY FORCE BLDG.	73020	BASE SUPPORT	$539,199	SF	1,152	1.00	15,957	DE	$0	$0	$24	0	0	1,152	$9,959	$7,122	$14,488	17	54	100	89	1943	67
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001030706	AV81	HOBBY SHOP ARTS & CRAFTS	74036	SAILOR AND FAMILY SUPPORT	$4,332,510	SF	15,549	1.00	10,072	DE	$0	$0	$190	0	0	15,549	$98,275	$57,958	$116,415	50	70	100	100	1941	69
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001038049	M202	EXCHANGE SERVICE OUTLETS (BA	74008	SAILOR AND FAMILY SUPPORT	$849,623	SF	2,856	1.00	0	DE	$0	$0	$37	0	0	2,856	$14,180	$11,620	$22,829	16	69	100	23	1941	69
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001031867	760	NAVSTA LEGAL BUILDING	61010	BASE SUPPORT	$9,913,700	SF	22,198	1.00	197,192	DE	$0	$0	$435	0	0	22,198	$114,846	$111,552	$266,382	100	91	96	100	1943	67
N60514-RM09-2831	DE	2012	138	N60514	NS GUANTANAMO BAY CUBA	NFA100001038076	M207	CLOSE BATTLE TRAINER	61010	BASE SUPPORT	$9,872,106	SF	22,534	1.00	197,192	RM	$0	$3,491	$0	0	25,146	0	$102,972	$131,369	$265,264	68	69	100	100	1941	69

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The final two worksheets are reference worksheets that do not have to be edited once they are set for the year. The first is the normalization table, which includes the data from previously completed demolition projects. This information allows us to calculate a normal distribution curve and normalize the new project raw values. Figure

18 is a screenshot of this worksheet. The worksheet can be expanded each year to include new executed projects.

Figure 18. cROI programming tool—normalization table

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CONSOLIDATION RETURN ON INVESTMENT (cROI) PROGRAMMING TOOL - NORMALIZATION

FY	UIC	PROJECT NO	PROJECT TITLE	PROJECT LOCATION	RPSUID	TOTAL CWE ($K)	FROI (NATURAL LOG)	FOOTPRINT REDUCTION (NATURAL LOG)	MDI	UTILIZATION	CONDITION	AGE (YEARS)
				MEAN			1.560	9.330	41.621	0.326	64.838	57.385
				STANDARD DEVIATION			1.022	1.718	25.400	0.344	18.523	20.550
2009	N00128	DE08-0217	DEMOLISH BUILDING 51	NAVSTA GREAT LAKES IL	194	$222	1.492	9.709	34.0	1.000	54.0	92.0
2009	N00129	DE08-0391	DEMOLITION IN SUPPORT OF NEW COMMISSARY	NAVSUBASE NEW LONDON CT	153	$1,777	-1.281	9.083	6.0		89.5	81.3
2009	N00206	DE08-0003	DEMOLISH BUILDINGS 37, 89, 122, 159, 418, & 902	NAS JRB NEW ORLEANS LA	141	$481	0.939	9.798	31.6	0.279	83.7	37.0
2009	N00207	DE09-0001	DEMOLISH VARIOUS FACILITIES	NAS JACKSONVILLE FL	168	$4,119	3.017	9.904	21.1	0.003	72.6	67.4
2009	N00245	DE08-0140	DEMOLISH TEST BUILDING, POST OFFICE, AND DIVERS SHOP	NAVSTA SAN DIEGO CA	181	$731	0.893	10.581	55.3	0.066	73.5	48.7
2009	N00245	DE08-0141	DEMOLISH DDDC WAREHOUSE B-3302	NAVSTA SAN DIEGO CA	181	$2,106	1.759	11.112		0.874		27.0
2009	N00245	DE08-0182	DEMOLISH BLDGS 3053, 3591, AND 3592	NAVSTA SAN DIEGO CA	181	$345	1.767	9.059	54.5	0.423	63.0	40.7
2009	N00245	DE08-0183	DEMOLISH BLDGS 3368, 3370, AND 3603	NAVSTA SAN DIEGO CA	181	$588	2.358	9.132	35.9	0.736	57.1	22.0
2009	N00245	DE09-0207	DEMOLISH BUILDING 3493	NAVSTA SAN DIEGO CA	181	$33	2.086	6.286	60.0	0.000	84.0	15.0
2009	N00245	DE09-0208	DEMOLISH BUILDING 88	NAVSTA SAN DIEGO CA	181	$833	1.858	9.711	68.0	0.000	69.0	66.0
2009	N00245	DE09-0213	DEMOLISH PIER 14	NAVSTA SAN DIEGO CA	181	$3,480	2.310	9.172	12.0	0.000	45.0	63.0
2009	N00246	DE07-0001	DEMOLISH 8 FACILITIES AND CONSOLIDATE FUNCTIONS	NAS NORTH ISLAND SAN DIEGO CA	180	$2,292	1.054	11.458	66.7	0.286	77.7	70.3
2009	N00620	DE02-0102	DEMOLISH VARIOUS BUILDINGS NWSTF BOARDMAN, OR	NAS WHIDBEY ISLAND WA	1015	$489	1.393	9.457	43.5	0.602	62.4	53.5
2009	N00620	DE04-0101	DEMOLISH RADIO TOWER AND EQUIPMENT	NAS WHIDBEY ISLAND WA	1017	$178	2.512	7.511	4.7	0.078	65.7	26.0
2009	N00620	DE09-1119	DEMOLISH VARIOUS BUILDINGS	NAS WHIDBEY ISLAND WA	193	$438	1.772	9.088	27.9	0.571	67.9	49.3
2009	N00620	DE09-1186	DEMOLISH SECURITY BUILDINGS AND CONSOLIDATE	NAS WHIDBEY ISLAND WA	193	$3,170	2.686	9.747	82.2	0.963	69.4	58.4
2009	N00620	DE09-2096	DEMOLISH 17A & 17 (PORTION OF NEX)	NAS WHIDBEY ISLAND WA	290	$209	1.679	8.266	69.0	0.217	64.0	52.8
2009	N0428A	DE07-0061	DEMOLISH 19 BUILDINGS (NRC SOLOMONS)	NAS PATUXENT RIVER MD	907	$1,093	2.201	9.850		0.000	63.9	62.2
2009	N31188	DE09-0501	DEMOLISH BUILDING 88A	NGSA SUGAR GROVE WV	173	$38	3.175	5.298			78.0	21.0
2009	N32411	DE08-0329	DEMOLISH BUILDINGS 85 CHI AND 1931 CP	NAVSTA NEWPORT RI	200	$673	0.488	10.345	20.4	0.305	62.6	83.7
2009	N32411	DE09-0103	DEMOLISH ABANDONED STEAM LINES	NAVSTA NEWPORT RI	200	$793						
2009	N32414	DE08-0190	DEMOLISH VARIOUS BUILDINGS (PNY-ANNEX)	NAVSUPPACT MECHANICSBURG PA	972	$2,100	0.399	12.083	28.0	0.390	54.0	67.3
2009	N47609	DE05-0001	DEMOLISH GROVES SCHOOL	NAWS CHINA LAKE CA	201	$809	1.026	9.992		0.000	63.6	55.9
2009	N57095	DE08-0388	PARTIAL DEMOLITION TO NH-18	NSA NORFOLK VA	161	$682	1.015	7.842	41.0	0.000	75.0	42.0
2009	N60042	DE09-0244	DEMOLISH BUILDING 409	NAF EL CENTRO CA	174	$1,100	0.929	10.276	47.0	0.000	58.0	64.0
2009	N60042	DE09-0245	DEMOLITION OF STORAGE WAREHOUSE	NAF EL CENTRO CA	174	$403	2.747	7.601		0.190	58.0	63.0
2009	N60241	DE05-0001	DEMOLISH BUILDINGS 2700 AND 3720	NAS KINGSVILLE TX	205	$2,456	1.545	10.817	23.2	0.842	93.8	50.1
2009	N61008	DE09-1228	DEMOLISH OLD BUNKERS	NSA PANAMA CITY FL	257	$540	2.772	7.665	19.8	0.399	69.1	60.5
2009	N61014	DE09-0201	DEMOLISH/CONSOLIDATE B351, B428, AND B349	NAVSUPPDET MONTEREY CA	258	$543	2.005	8.672	44.7	0.000	72.9	21.4
2009	N61014	DE09-3013	DEMOLISH BUILDING 249	NAVSUPPDET MONTEREY CA	509	$40	2.044	5.991		0.000	78.0	57.0
2009	N61018	DE09-3277	DEMOLISH MINEFILL BUILDINGS & BERM	NSA CRANE IN	246	$1,700	2.699	9.257	12.0	0.062	84.0	66.6

Because we used most of the Navy's FY 2009 and FY 2010 demolition projects to populate the initial baseline, we show a shortened version of the large table. The normalization table worksheet contains the control data fields to build the normalization graph indicators that are located on each benefit score worksheet. These tables use the metric mean and standard deviation to build a standardized normalization curve that shows the relationship of the current project metric to the mean. There is one control table for each metric. None of the tables in the normalization worksheet require user input or manipulation after the previous year's project values are appended to the existing list.

The final worksheet is a documentation sheet. It provides reference information to inform the users which version of the model they have

and which data sources were used as inputs for this evaluation. Figure 19 provides a sample model documentation sheet.

Figure 19. cROI programming tool—model documentation

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OPNAV N46 | **CONSOLIDATION RETURN ON INVESTMENT (cROI) PROGRAMMING TOOL - DOCUMENTATION**

Model version control

Version:	1.0
Date created:	13-Mar-2012
Designer:	Center for Naval Analyses
Contact:	Dr. Burton L. Streicher, PE
	streichb@cna.org
Changes since initial release:	None

CNA

Data version control

Project Number:	RM09-2831
Created by:	Dr. Burton L. Streicher, PE
Date created:	13-Mar-2012
Baseline FY:	2010
Source data	
iNFADS	EOFY 2010
FXM:	13-3
Financial:	EOFY 2010

THIS PROGRAMMING TOOL GENERATES A CONSOLIDATED BENEFIT RATING BASED UPON PROJECTED REDUCTIONS OF ANNUAL FACILITY SUSTAINMENT COST, FACILITY MODERNIZATION COST, BASE OPERATING SERVICES COST, AVERAGE INVENTORY AGE, AND INFRASTRUCTURE FOOTPRINT, MERGED WITH IMPROVEMENTS IN MISSION DEPENDENCY AVERAGES, UTILIZATION, AND OVERALL CONDITION RATING FOR EACH PROPOSED DEMOLITION RELATED INVESTMENT PROJECT.

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A user guide is provided in appendix A, which goes through the steps for updating the model version, completing the worksheet, and evaluating the results. We also developed a field version of this model. That version does not link to the DD Form 1391 project file or include the additional facility demographic information that is related to the installation. Neither the form nor the additional demographic information are essential for calculating the benefit rating. The sponsor's intention is to provide this version of the model to the installations to assist them with development of more robust consolidation projects. Electronic copies of both models are included in appendix B.

Sample rating

To build and test the cROI model, we used information from consolidation project RM09-2831, "Consolidation to M207 and Demolition," submitted by Naval Station Guantanamo Bay, Cuba. This project proposes to renovate and convert building M207, which formerly supported a close battle trainer, into an administrative office facility. It also proposes consolidating the personnel from 13 smaller facilities; those buildings can then be demolished. The project scope is dated July 12, 2009, and is estimated to cost $4,461,000.

Table 2 provides the evaluation results for each of the six metrics used to calculate the ROI composite score for the project.

Table 2. RM09-2831 project evaluation results

Metric	Raw value	Benefit score	Weight	Benefit contribution
Financial	4.38 years	0.5320	49.4%	0.2628
Footprint	67,409 SFE	0.8510	34.8%	0.2962
Mission	70	0.1305	4.9%	0.0064
Utilization	29.0%	0.4579	0%	0.0000
Condition	79.0	0.2221	10.9%	0.0242
Age	59.6 years	0.5436	0%	0.0000
Composite total score				**0.5896**

This evaluation indicates that this project is an excellent candidate for programming in FY 2014 as its life-cycle cost return is less than the threshold of 6.0 years for payback. In addition, it has a large footprint reduction amount, an average category surplus reduction, and an average age of facilities demolished. The only areas that should be discussed with the project sponsor are the relatively high MDI and condition rating of the facilities being demolished. This will allow for validation of the MDI and condition rating scores within iNFADS. However, overall this project will compete well for programming because of its above average composite total score.

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Multiple project example

OPNAV N46 gave us a list of 18 candidate consolidation projects (14 special projects and 4 military construction projects) to evaluate using this new tool. Table 3 provides the results of our evaluation. They are listed in order of descending ROI composite scores.

Table 3. Multiple project evaluation results

Project number	Project title	Location	Cost ($K)	FROI (years)	Composite score
DE09-2367	Consolidate B141/156 and demolish B148	NAVSUBASE New London, CT	$826	1.85	0.7413
DE09-2179	Consolidate bays in B27	NSA Mechanicsburg, PA	$5,767	5.62	0.6030
DE09-1999	Consolidate and demolish two buildings	NAS Lemoore, CA	$1,645	5.39	0.4616
DE07-0003	Consolidate fitness facilities & demolish various structures	NAVBASE Ventura County Pt Mugu, CA	$1,229	2.67	0.6789
DE07-0100	Consolidate 8 buildings at Carderock	NSA North Potomac, MD	$635	2.47	0.6265
DE09-2411	Repair B510/B152 & demolish B208	NSA Mechanicsburg, PA	$4,865	6.80	0.6089
DE08-0213	Consolidate B140 & demolish B155 MWR office	NAVSTA Great Lakes, IL	$362	2.40	0.6082
DE07-0007	Consolidate EOD into B22 and demolish 6 facilities	NAS Whidbey Island, WA	$2,900	4.48	0.6075
RM09-2831	Consolidate M207 and demolish 13 facilities	NAVSTA Guantanamo Bay, Cuba	$4,461	4.38	0.5896
P807	TSC applied instruction facility	NAVSTA Great Lakes, IL	$52,260	7.05	0.5386
DE01-0012	Consolidate PSD/NAVPTO/SATO and demolish B92	NSA Washington, DC	$2,639	4.44	0.5661
DE09-1940	Consolidate SWOS trainers B138 & B1164	NAVSTA Newport, RI	$1,729	5.22	0.5152
P622	Air traffic control facility	NAS Jacksonville, FL	$49,930	18.02	0.4411
P491	Combat vehicle maintenance shop	NAVBASE Ventura County Pt Mugu, CA	$27,510	36.05	0.4304

Table 3. Multiple project evaluation results

Project number	Project title	Location	Cost ($K)	FROI (years)	Composite score
DE10-0057	Consolidate fire inspectors and demolish B57	NSA Washington, DC	$792	5.24	0.4153
P229	Strategic systems weapons evaluation test	NAVWPNSTA Seal Beach, CA	$32,960	69.31	0.3665
RM10-9009	Consolidation of aircraft crash rescue and fire HQ	NAS Key West, FL	$10,693	21.52	0.3466
DE11-7522	Consolidate MWR admin in rec mall and demolish B352	CBC Gulfport, MS	$2,344	23.30	0.2094

Only 11 of the projects generate a FROI score that is less than the life-cycle cost return hurtle rate of 6.0 years. Of these 11, only project DE10-0057 has a composite score that is below the average mean. The remaining ten projects, valued at $22.2 million, should form the candidate project pool for selection. Electronic copies of these individual project evaluation worksheets and their corresponding project scope and cost estimate documents are included in appendix B. There are several methods for selecting the optimum projects depending on the amount of funding available to support the program. In the next section, we will discuss some issues related to program evaluation.

Process for program evaluation

At various levels within the Navy, decisions must be made on the allocation of scarce resources. In these decisions, the Navy seeks to allocate the budget imposed by Congress in such a way as to maximize benefits for the United States. One method for making these decisions is to construct a linear combination of several different benefits accruing to each program that gives a single cardinal index of overall benefits to each program. One can then choose the allocation of resources among different programs that maximizes an overall cardinal index of benefits to the Navy.

The advantage of this approach is that, when used at the individual program office, it gives a very quick initial answer to the allocation problem. We applied this selection approach in our multiple project example. The disadvantage of this approach is that it may be an oversimplification of the overall allocation problem since the benefit derived from separate governmental programs cannot always be easily measured using cardinal numbers.[3] In addition, the benefit derived from one program may depend on the level of spending on other programs, making it difficult to compare the benefits derived from different market baskets (combinations) of all governmental programs.

However, the benefits from different budget allocations that stay within the budget constraint can be given an ordinal rank when compared with other budget allocations with pair-wise comparisons by Navy subject matter experts.[4] Given a budget, we need to reveal the preferences of these experts who must choose among the affordable combinations of governmental programs. We discuss how this

3. The idea that many problems are too complex to be solved by simple mathematical models has a long history in decision-making. See, for example, the work on bounded rationality by Simon (1957) [2] and Simon (1991) [3].

approach can be applied using the cROI tool generated scores to select which consolidation projects to fund for a given budget.

Introduction

The underlying assumption of the revealed preference market basket approach is that the benefit derived from separate governmental programs cannot always be easily measured using cardinal numbers.[5] Even more difficult is measuring and comparing the benefits derived from different market baskets (combinations) of governmental programs.

Statement of budget problem: consolidation project selection

The Director, Shore Readiness Division (OPNAV N46) must make recommendations about which consolidation projects to fund. More generally, the director must make facility funding decisions for the Navy as a whole. Relying on the OSF strategy as a link between naval operations and facility condition and size, the Director must choose among a diverse assortment of funding options to determine which options will best achieve the goals of the U. S. Navy and the United States as a whole.

We previously presented a single cardinal index number approach for making such funding decisions using the project scores generated by the cROI tool. We now present another method for refining the single cardinal index number approach to take account of the complexities of the problem not addressed by that approach.

A revealed preference and market basket approach

The single index number approach to rank consolidation projects for funding has the following drawbacks:

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4. This is often referred to as the knapsack problem in the decision science literature. For a discussion of the knapsack problem and how to solve it, see Soland (1979) [4] and Steuer (Chapter 13, 1986) [5].
5. See Trost and Ye (2003) [6] for a further discussion of this problem.

- It relies too heavily on cardinal rather than ordinal simple rank measurements.
- It does not consider complementarities and substitutability among the six criteria. Doing so would allow for the possibility that the whole is greater than the sum of the parts within any one project. A popular term for this concept is synergy. Economists call this concept the complementarity between two separate criteria.
- The cardinal index number approach evaluates each project separately rather than comparing different market basket combinations of projects. Hence, the resulting combination of projects based solely on cROI benefit score magnitude may not be optimal for a given budget. As with different criterion within a project, there may be synergy between two or three different consolidation projects.
- The size of the budget is not explicitly incorporated into the decision process since the size of the budget does not alter the individual ranking of projects.
- The approach assumes that all criteria are measured without error, both in general and within a separate project.

Given these potential shortcomings, we suggest four ways for improving the simple cardinal index number program development approach:

- Use the theory of revealed preference and pair-wise ordinal comparisons to evaluate the benefits of individual projects relative to one another.
- Compare the benefits of different affordable market baskets.
- Base the final decision on the market basket of projects that is optimal for a given budget.
- Assign an accuracy index to each criterion within each project.

Consolidation project program selection example

We will describe how to implement the first three improvements in a simple example. We use the top ten cROI ranked consolidation projects from our analyses to provide a candidate list of projects for selection.

Let the 10 projects that are considered for funding be denoted by X. Let the subscript i be the ith project, i = 1, 2, …, 10. We have the cost of each of these projects, denoted P_i, for the cost of the ith project.

The maintained hypothesis is that the exact benefit the Navy will receive by funding a single project or basket of projects is unknown and is potentially not measurable using ordinal numbers only. Given a budget, denoted B, our goal is to reveal the preferences of those who must choose among the affordable combinations of the ten projects.

For any given market basket of tasks, denoted J(k), it must be true that

$$\sum_{J=1}^{\;\;j=J(k)} P_{j(k)} \leq B$$

where subscript j(k) is the jth project of the total J(k) projects in the kth market basket.

Suppose there are K different affordable baskets for a given budget B. Our goal is to find the optimal basket, k* from all market baskets (choice sets) of k = 1, 2, …, K.

Table 4 lists the top ten projects, that meet the FROI hurtle rate, in the order they are ranked by the cardinal index number approach.

Table 4. Top ten consolidation projects as ranked by composite score

Rank	Project#	Project title	Installation name	CWE ($K)	FROI	Composite score
1	DE09-2367	Consolidate B141/156 and demolish B148	NAVSUBASE New London, CT	$826	1.85	0.7413
2	DE07-0003	Consolidate fitness facilities & demolish various structures	NAVBASE Ventura County Pt Mugu, CA	$1,229	2.67	0.6789
3	DE07-0100	Consolidate 8 buildings at Carderock	NSA North Potomac, MD	$635	2.47	0.6265
4	DE08-0213	Consolidate B140 & demolish B155 MWR office	NAVSTA Great Lakes, IL	$362	2.40	0.6082
5	DE07-0007	Consolidate EOD into B22 and demolish 6 facilities	NAS Whidbey Island, WA	$2,900	4.48	0.6075
6	DE09-2179	Consolidate bays in B27	NSA Mechanicsburg, PA	$5,767	5.62	0.6030
7	RM09-2831	Consolidate M207 and demolish 13 facilities	NAVSTA Guantanamo Bay, Cuba	$4,461	4.38	0.5896
8	DE01-0012	Consolidate PSD/NAVPTO/SATO and demolish B92	NSA Washington, DC	$2,639	4.44	0.5661
9	DE09-1940	Consolidate SWOS trainers B138 & B1164	NAVSTA Newport, RI	$1,729	5.22	0.5152
10	DE09-1999	Consolidate and demolish two buildings	NAS Lemoore, CA	$1,645	5.39	0.4616

Table 5 re-orders these ten projects from least expensive to most expensive.

Table 5. Top ten consolidation projects in ascending order of cost

Rank	Project#	Project title	Installation name	CWE ($K)	FROI	Composite score
1	DE08-0213	Consolidate B140 & demolish B155 MWR office	NAVSTA Great Lakes, IL	$362	2.40	0.6082
2	DE07-0100	Consolidate 8 buildings at Carderock	NSA North Potomac, MD	$635	2.47	0.6265

Table 5. Top ten consolidation projects in ascending order of cost

Rank	Project#	Project title	Installation name	CWE ($K)	FROI	Composite score
3	DE09-2367	Consolidate B141/156 and demolish B148	NAVSUBASE New London, CT	$826	1.85	0.7413
4	DE07-0003	Consolidate fitness facilities & demolish various structures	NAVBASE Ventura County Pt Mugu, CA	$1,229	2.67	0.6789
5	DE09-1999	Consolidate and demolish two buildings	NAS Lemoore, CA	$1,645	5.39	0.4616
6	DE09-1940	Consolidate SWOS trainers B138 & B1164	NAVSTA Newport, RI	$1,729	5.22	0.5152
7	DE01-0012	Consolidate PSD/NAVPTO/SATO and demolish B92	NSA Washington, DC	$2,639	4.44	0.5661
8	DE07-0007	Consolidate EOD into B22 and demolish 6 facilities	NAS Whidbey Island, WA	$2,900	4.48	0.6075
9	RM09-2831	Consolidate M207 and demolish 13 facilities	NAVSTA Guantanamo Bay, Cuba	$4,461	4.38	0.5896
10	DE09-2179	Consolidate bays in B27	NSA Mechanicsburg, PA	$5,767	5.62	0.6030

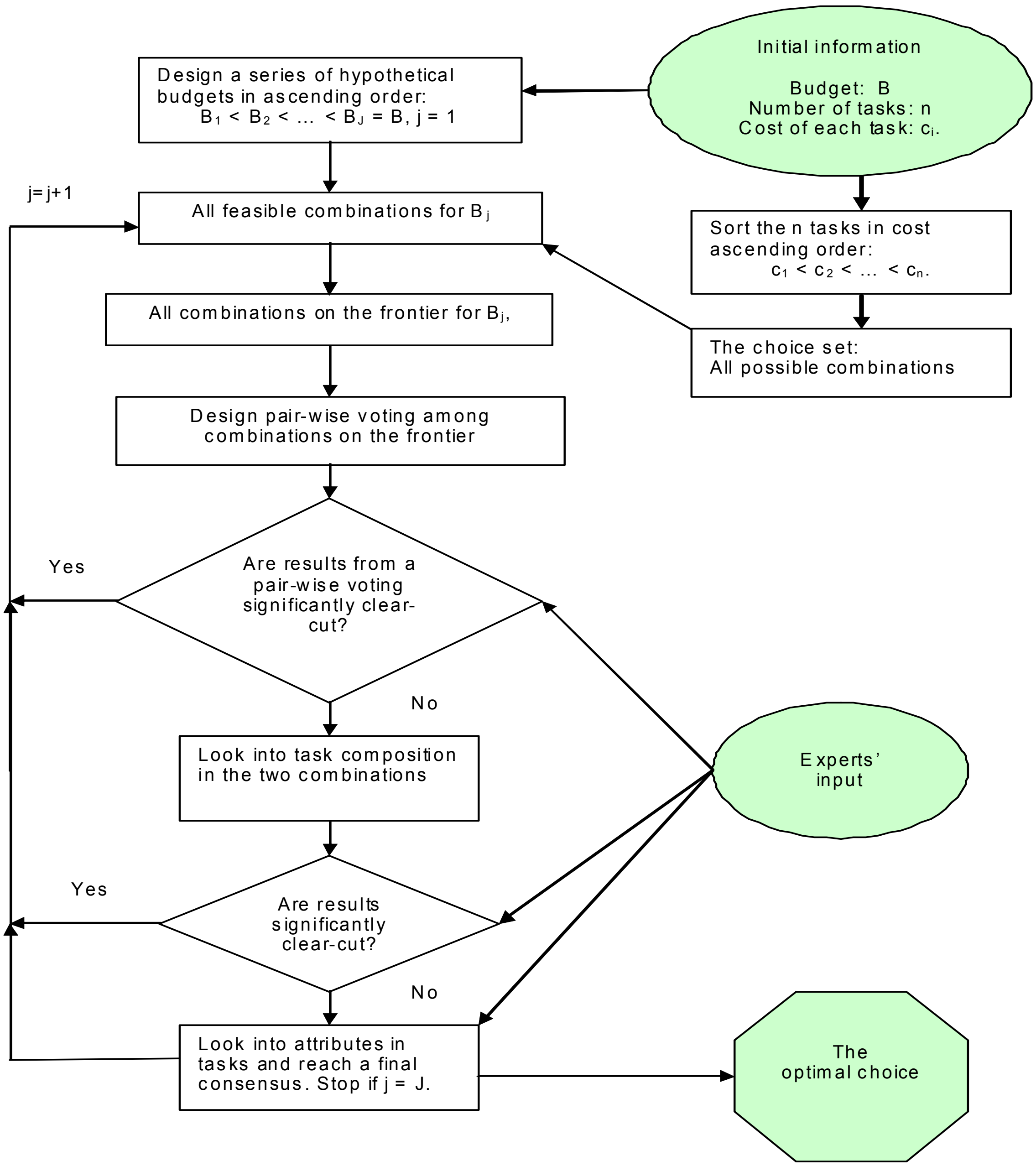
The ranking listed in table 4 has at least two flaws if used solely to select projects for funding. First, looking at table 5, if the program budget were $1 million, the first two lowest-cost individual projects are affordable. However, in table 4, only the lowest ROI composite score project DE09-2367, "Consolidate building 141/156 and demolish building 148" is affordable with a $1 million budget. So, this is where Navy subject matter experts need to decide between the affordable combinations of projects versus each of the individual project's cost and ROI composite benefit score. The index number approach gives no clear guidance on how to make this choice. Second, if the budget is $5 million, only the first four of the ranked projects are affordable. However, if we allow experts to vote on the first four items versus an alternative bundle of the five lowest cost projects at a cost of about $4.7 million, the experts may well choose the larger bundle of five projects versus the cardinal index number approach of only funding the first four ranked projects.

The example demonstrates that there is really no universal project portfolio, but rather many budget-specific alternative combinations

of projects. Using a revealed preferences approach,[6] one can choose which affordable bundle to fund through pairwise comparison of project preferences. Figure 20 gives a process flow chart for applying a revealed preference approach, as discussed in Trost and Ye (2003) [6].

6. This basic approach is also used in the Analytical Network Processing (ANP) software, as opposed to the Analytical Hierarchy Processing (AHP) software which takes the cardinal index number approach. See Satty (1994) [7] and Saaty (2005) [8] for a discussion of the AHP and ANP decision-making software, respectively.

Figure 20. Flow chart of revealed preference market basket approach



Finally, a method to implement the fourth recommended improvement is to add an attribute to each criterion within a project that captures the accuracy of how well that criterion is measured. This introduces an important significance variable, which can be assessed when evaluating the cROI benefit scores.

The full portfolio of consolidation projects were not available in time for us to evaluate and demonstrate a revealed preference and market basket approach for populating a budget restrained program selection process. However, we hope the previous limited example and discussion will help guide future utilization of the approach.

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Recommendations

We have the following recommendations for the Navy to consider when using this new evaluation tool.

Better consolidation project identification

The Navy should pursue a process that facilitates identification of greater numbers of better consolidation projects. The success of the consolidation program is primarily dependent on the quality of the projects funded and implemented. This process starts with project development at the base and CNIC region level. The cROI evaluation tool is only helpful if it is used to compare a robust set of projects that in total exceed the consolidation program's budget.

The development of consolidation projects is not an easy process. It often requires working with facility tenants who have had the luxury of extra space or their own dedicated facilities. An effective consolidation project often requires them to move to much smaller spaces and to share facilities with other organizations.

We recommend that N46, CNIC, and NAVFAC work together to develop and publish guidance concerning consolidation project preparation with the goal of generating more worthwhile projects. Identification of a consolidation project should not be a voluntary or optional process when underutilized facilities exist on a base. When better facility utilization information becomes available, as is expected, just providing oversight will become an easier option. However in the interim, greater policy direction and pressure is needed to improve the quality of consolidation project submissions.

Leverage OSF strategy for project development

We suggest that the OSF strategy process be leveraged to support more direct development of consolidation projects. The current OSF

strategy, as we understand it, does not leverage the involved organization's capabilities to influence the near-term preparation of more consolidation projects. We believe that, because of the organizations involved, the OSF organization could provide an ideal source of direction to the bases and regions concerning consolidation projects. More specific policy direction as part of the OSF strategy may help overcome some of the challenges at the base and region level to be more aggressive in developing consolidation projects.

Improve the individual evaluation factor weights

We recommend that the OSF working groups continue to pursue the improvement of the individual evaluation factor weights. The cROI tool output included in this report uses the initial four factor weights provided to us to generate the scores for the 18-project sample set. Both the utilization improvement and facility age evaluation factors were zeroed out. We recommend that the Navy review the project rankings that resulted from those initial factor weights and better align the weights to the overall OSF strategy.

We designed the cROI tool to easily accommodate changes to the factor weights. As the Navy continues to review the weighting options, we recommend that the tool's capability be used to perform sensitivity analyses to determine how various weighting options change the relative scores of the sample projects or new projects that may be identified.

Update the cROI tool normalization table

The Navy should update the cROI tool normalization table by appending future projects as they are completed. One of the major enhancements made to the previous dROI tool in the new cROI tool is the use of past approved projects to determine evaluation factor scores. The tool allows those historical data to be updated annually with results from the previous year. With these updates, the tool will better maintain its ability to provide comparative scores for future consolidation projects.

Revealed preference and market basket programming

We recommend that the Navy include a revealed preference and market basket approach to building annual facility consolidation project programs. This may become a more important option if the number of consolidation projects submitted significantly exceeds the program budget.

If, for example, the financial threshold requirement eliminates enough projects to allow most of the remaining projects to be funded, then using a rank order of cROI project evaluation scores may be sufficient. However, if a number of otherwise worthy projects score below a budget-derived cut line, then the revealed preference and market basket approach might be useful in determining the total group of approved projects that are more beneficial to the Navy than a group determined strictly by their cROI evaluation tool score.

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Appendix A: cROI user guide

Background

CNA developed a facility investment consolidation project evaluation tool to evaluate proposed consolidation/demolition projects for programming. This appendix describes how to use the evaluation tool developed in that report.

This cROI tool is based on the research presented in the CNA report, "Consolidation Return on Investment (cROI) Programming Tool: Development and Use." The mathematical model developed in that report is coded into one Microsoft Excel workbook. There are two outputs from this evaluation tool:

- A financial return on investment (FROI) threshold check
- A single consolidated project rating between zero and one

The project evaluation tool is in "20120313 cROI Model Template.xls." The field version of the tool is located in "20120313 cROI Field Model Template.xls."

User instructions

The main difference between the models is that the field version does not include installation background information and a link to the project scope document. Although less information is captured for future program reference, it does allow for a simpler calculation of the project benefit score.

Completion of cROI project evaluation tool

The cROI programming tool should be used to evaluate new consolidation/demolition projects in the following annual cycle.

1. Calculate actual project results from the previous execution year and append to the template normalization project list. Adjust the mean and standard deviation cell ranges for each of the six metrics to include the new projects.
2. Update the documentation page in the templates to identify the data sources to be used for this evaluation cycle.
3. Release the next cycle project submission call to the field with programming guidance. Include the current year version of the field model as part of the guidance.
4. After the submission cut-off date, extract candidate DD Form 1391 project scopes from the electronic project generator (EPG) as pdf files and place them in a data folder labeled "FYXX project vault."
5. Create blank cROI worksheets for each project for later evaluation. Populate the data worksheet with the pertinent project facility data by building the facility data table manually using the DD Form 1391 project information and iNFADS extracts.
6. Refresh the pivot table on the utilization worksheet to extract the new facility information. There should be one line for each affected facility category code.
7. On the summary page, fill in the installation data fields and project specific fields that are highlighted in blue for future reference; note that these are not necessary for the model to calculate the return on investment composite score.
8. Link the project DD Form 1391 pdf document from the project vault to the summary page through a reference hyperlink.
9. You have now completed the project worksheet and it can be saved and closed. If desired, to organize the project portfolio, the summary scores could be transferred to a master project list in a separate MS Excel worksheet.
10. After all the submitted consolidation/demolition projects have been evaluated and completed, the results should be stored for future reference in one data folder with an FYDP project programming master project summary list, a worksheet file for

each project, and the FYXX project vault subfolder containing the project DD Form 1391s.

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Appendix B: cROI programming tool electronic files

The Navy consolidation return on investment (cROI) programming tool prototype software model version 1.0 is attached to this report as an electronic Microsoft Excel worksheet. A simplified version 1.01 is also included for installation use in order to help shape future consolidation project submissions. These models were build to support the POM-13 budget development cycle. The models have to be reset with new normalization data in order to support later cycles.

File attributes

File name: 20120313 cROI Model Template.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: cROI Model Template
Author: Dr. Burton L. Streicher, PE
Size: 524 KB

File name: 20120313 cROI Field Model Template.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: cROI Field Model Template
Author: Dr. Burton L. Streicher, PE
Size: 521 KB

Project evaluation worksheets

As part of testing the new evaluation tool, sample project rating worksheets were developed for 18 previously submitted consolidation projects. These sample project evaluations are included in the following electronic files:

File name: 20120313cROI Model DE01-12.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE01-12 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 517 KB

File name: 20120313cROI Model DE03-07.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE03-07 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 520 KB

File name: 20120313cROI Model DE007-07.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE007-07 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 520 KB

File name: 20120313cROI Model DE09-1940.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE09-1940 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 517 KB

File name: 20120313cROI Model DE09-1999.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE09-1999 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 517 KB

File name: 20120313cROI Model DE09-2179.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE09-2179 cROI Evaluation

Author: Dr. Burton L. Streicher, PE
Size: 517 KB

File name: 20120313cROI Model DE09-2367.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE09-2367 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 517 KB

File name: 20120313cROI Model DE09-2411.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE09-2411 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 517 KB

File name: 20120313cROI Model DE11-7522.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE11-7522 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 516 KB

File name: 20120313cROI Model DE57-10.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE57-10 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 518 KB

File name: 20120313cROI Model DE100-07.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project DE100-07 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 521 KB

File name: 20120313cROI Model DE0213-08.xls
File type: MS Excel 97-2003 worksheet

Date: 16 March 2012
Title: Project DE213-08 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 517 KB

File name: 20120313cROI Model P229.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project P229 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 517 KB

File name: 20120313cROI Model P491.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project P491 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 525 KB

File name: 20120313cROI Model P622.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project P622 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 522 KB

File name: 20120313cROI Model P807.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project P807 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 521 KB

File name: 20120313cROI Model RM10-9009.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project RM10-9009 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 517 KB

File name: 20120313cROI Model RM09-2831.xls
File type: MS Excel 97-2003 worksheet
Date: 16 March 2012
Title: Project RM09-2831 cROI Evaluation
Author: Dr. Burton L. Streicher, PE
Size: 524 KB

Project DD Form 1391 documents

The individual DD Form 1391 project scope and cost estimates for each project are located in the following files and can be opened using the links within the project evaluation worksheets.

File name: N00128-DE08-0213.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 12.5 KB

File name: N00128-P807.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 32.9 KB

File name: N00129-DE09-2367.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 9.5 KB

File name: N00207-P622.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 44.0 KB

File name: N00213-RM10-9009.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 22.0 KB

File name: N00620-DE07-0007.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 16.7 KB

File name: N32411-DE09-1940.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 16.5 KB

File name: N32414-DE09-2179.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 10.3 KB

File name: N32414-DE09-2411.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 12.9 KB

File name: N60515-RM09-2831.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope

Author: Oracle Reports
Size: 15.0 KB

File name: N61065-P229.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 38.5 KB

File name: N61142-DE01-0012.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 10.2 KB

File name: N61142-DE10-0057.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 12.0 KB

File name: N62604-DE11-7522.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 16.9 KB

File name: N63042-DE09-1999.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 13.8 KB

File name: N68469-DE07-0100.pdf
File type: Adobe Acrobat Document

Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 12.6 KB

File name: N69232-DE07-0003.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 13.4 KB

File name: N69232-P491.pdf
File type: Adobe Acrobat Document
Date: 6 October 2011
Title: DD Form 1391 Project Scope
Author: Oracle Reports
Size: 51.8 KB

Glossary

A

AHP	Analytical hierarchy processing
ANP	Analytical network processing

B

BOS	Base operating support

C

CAP	Capacity rating
CCN	Category code number
CND	Condition
CNIC	Commander, Navy Installations Command
CNO	Chief of Naval Operations
cROI	Consolidation return on investment
CWE	Current working estimate

D

DE	Demolition
DOD	Department of Defense
dROI	Demolition return on investment

E

EPG	Electronic project generator
EOD	Explosive ordnance disposal

F

FM	Facilities modernization
FMM	Facilities modernization model
FROI	Financial return on investment
FSM	Facilities sustainment model
FXM	Facilities sustainment, modernization, and operation models
FY	Fiscal year

G

H

I

iNFADS	Internet Naval Facilities Assets Data Store

J

K

L

M

M	Modernization
MDI	Mission dependency index
MWR	Morale, welfare, and recreation

N

NAVFAC	Naval Facilities Engineering Command
NAVPTO	Navy Passenger Transportation Office

NF	New footprint
NPV	Net present value

O

OPNAV	Office of the Chief of Naval Operations
OSD	Office of the Secretary of Defense
OSF	Optimal Shore Footprint

P

PRV	Plant replacement value
PSD	Personnel support department

Q

R

R	Restoration
ROI	Return on investment
RPSUID	Real property site unique identifier

S

SATO	Scheduled air transportation office
SF	Square feet
SFE	Square feet equivalent
ST	Sustainment
SWOS	Surface warfare officer's school

T

TSC	Training support center

U

UIC	Unit identification code

UOM	Unit of measure

V

W

X

Y

Z

References

[1] Burton L. Streicher and Dan Steeples. *Navy Excess Infrastructure: Review, Identify, and Reduce through Improved Demolition Program Processes.* CNA Research Memorandum D0020422.A2/Final. Jul. 2009.

[2] Herbert A. Simon. *Models of Man.* New York: John Wiley and Sons, 1957.

[3] Herbert A. Simon. "Bounded Rationality and Organizational Learning." *Organization Science* 2, no. 1, Feb. 1991: 125–134.

[4] Richard M. Soland. "Multicriteria Optimization: A General Characterization of Efficient Solutions." *Decision Sciences* 10, 1979: 26–38.

[5] Ralph E. Steuer. *Multiple Criteria Optimization: Theory, Computation, and Application.* New York: John Wiley and Sons, 1986.

[6] Robert P. Trost and Michael Ye. *Choosing R&D Technology Investments.* CNA Research Memorandum D0007330.A2/Final. 2003.

[7] Thomas L. Saaty. *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process.* Pittsburgh: RWS Publications, 1994.

[8] Thomas L. Saaty. *Theory and Applications of the Analytic Network Process: Decision Making with Benefits, Opportunities, Costs, and Risks.* Pittsburgh: RWS Publications, 2005.

[9] *DoD Facilities Pricing Guide for FY 2010.* Department of Defense Unified Facilities Criteria (UFC) 3-701-01. 2010.

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